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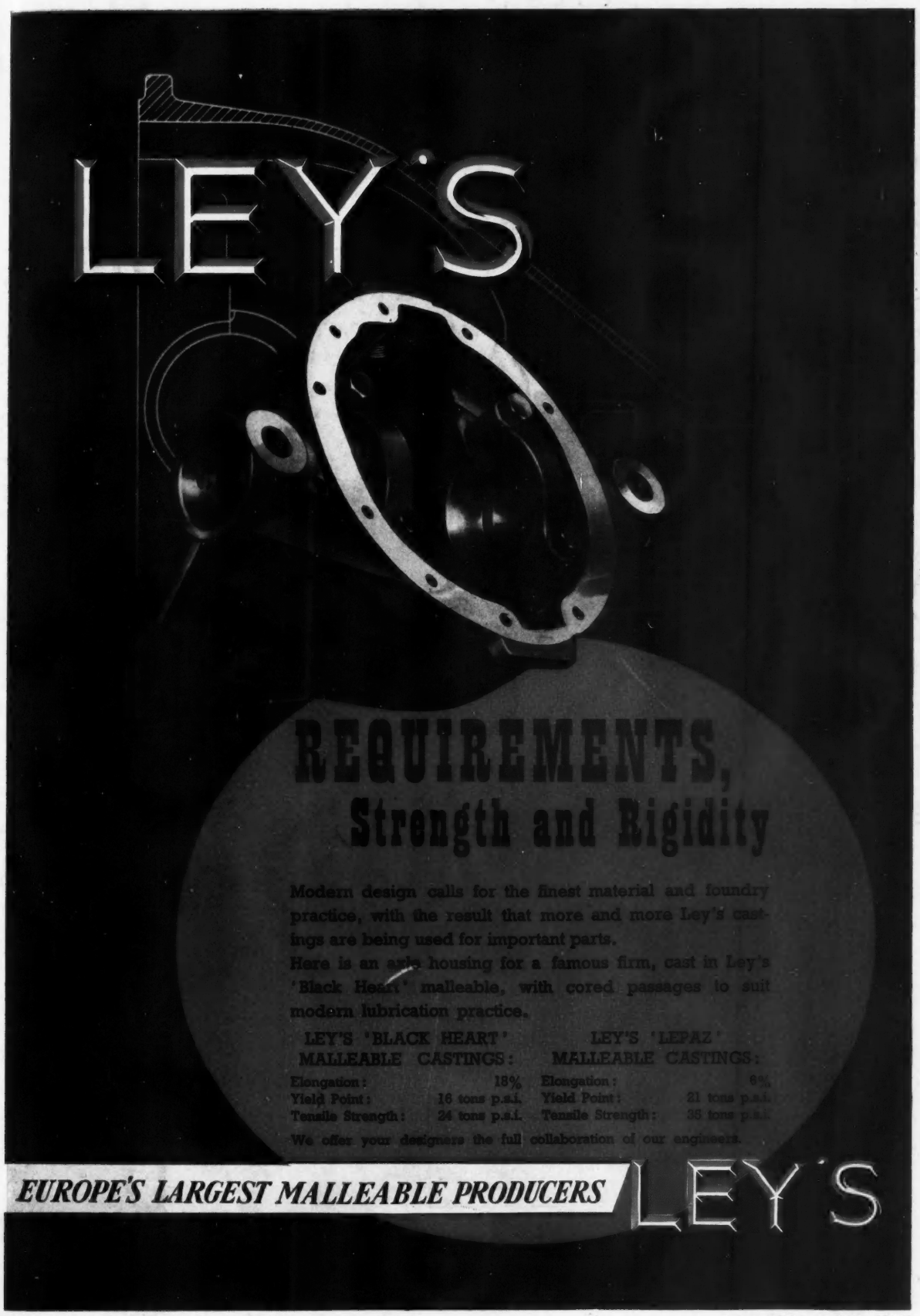
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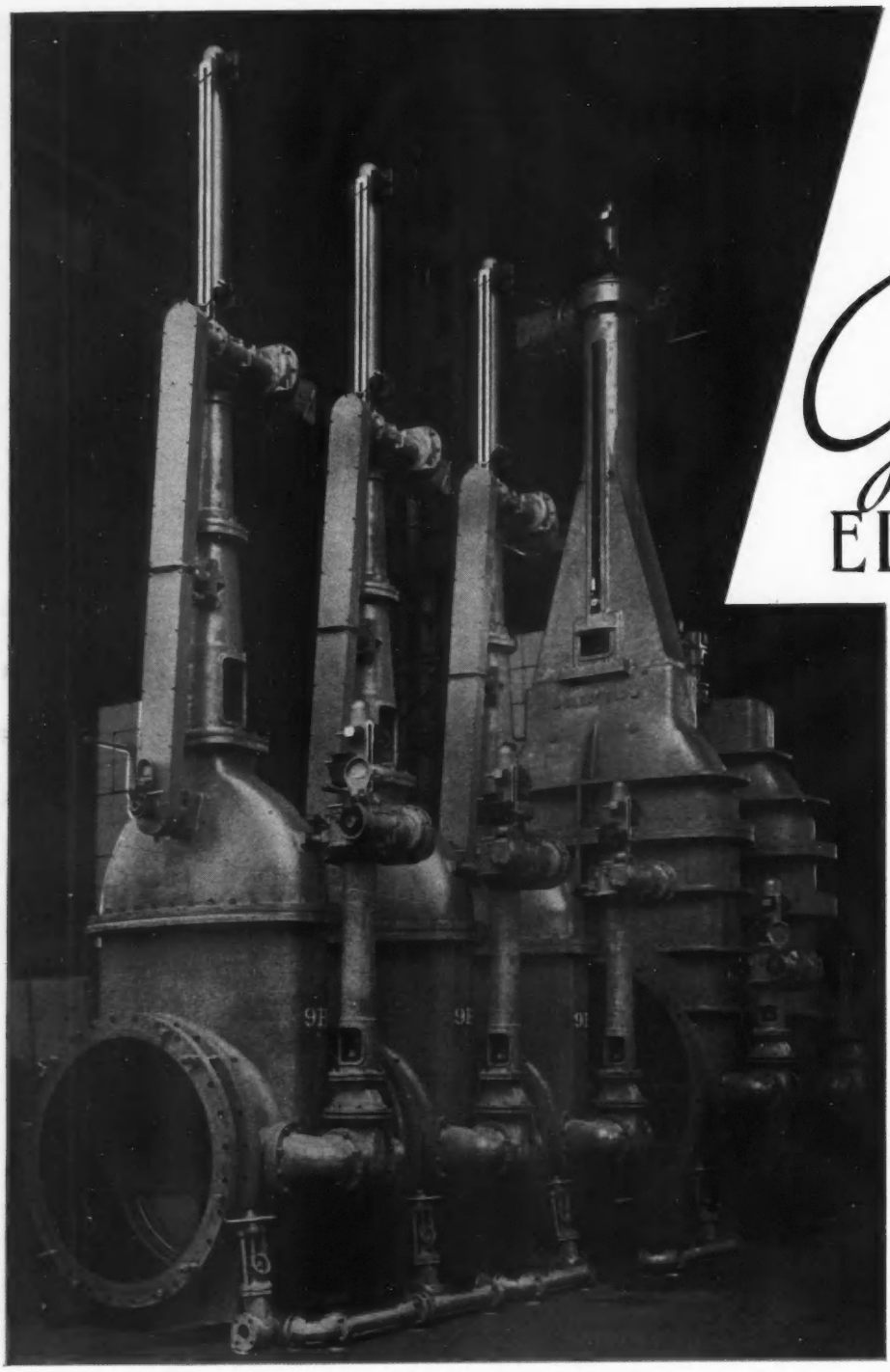

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THE ENGINEER

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CONTENTS

LEADING ARTICLES—
Coming Aircraft Production Methods... 41
Human Aspects of Repetitive Work ... 42

ARTICLES—
A.B.C. Conference on the Unification of Engineering Standards 43
British Railways in 1955 47
Centenary of the London General Omnibus Company 43
Civil Engineering in 1955. No. II. (Illus.) 49
Coal in 1955. No. I 62
Continental Engineering in 1955. No. II. (Illus.) 64
Dr. F. Sherwood Taylor 43
Education Within Industry 43
Electrical Engineering in 1955. No. II. (Illus.) 52
Gas Turbines in 1955. No. I. (Illus.)... 59
Generating Plant Commissioned by the C.E.A. in 1955 72
I.Mech.E. Staff Appointments 43
Large Milling Cutter Gang. (Illus.) ... 77
Naval Construction in 1955. No. II. (Illus.) 68
Nuclear Power for Commercial Vessels. (Illus.) 74
Operation of Two New Hydro-Electric Power Stations 43
Royal Navy in 1955. No. II. (Illus.)... 44
Shipbuilding and Marine Engineering in 1955. No. II. (Illus.) 56
Sluice Gates of the Ghulam Mohammed Barrage 77
100 Years Ago 42

LITERATURE—
Books of Reference 51
Books Received 51

NEWS AND NOTES—
British Patent Specifications. (Illus.)... 79
Calendars and Diaries 80
Catalogues and Brochures 80
Code of Practice 76
Forthcoming Engagements 80
Industrial and Labour Notes 73
Personal and Business 78
Technical Reports 67

SIXTEEN ART PLATES—
Iron and Steel Works
Large British Machine Tools of 1955 (2)
Steam and Oil-Engined Cargo Ships (2)
Structures in Steel and Prestressed Concrete in 1955
Substations of the Central Electricity Authority
Two Overseas Civil Engineering Works
Aeronautical Gas Turbines
Research and Development Establishments
Gas Works Extensions in 1955
Some Small Vessels of 1955
Special Purpose Ships of 1955
Continental Hydro-Electric Schemes
Atomic Energy in the United States in 1955
Bridge Construction in the United States

COMING AIRCRAFT PRODUCTION METHODS

Last week, at the annual conference on the problems of aircraft production, organised by the Southern Section of the Institution of Production Engineers, a critical review of the state of the aircraft industry was presented by Sir Roy Fedden. While some of his proposals, such as the major one that aircraft procurement should be the responsibility of the Air Ministry and not the Ministry of Supply, are undoubtedly matters of public concern, we can find some weight in the view voiced at the conference that incessant criticism of the industry can do harm by tarnishing the glamour attaching to a very advanced and difficult branch of engineering. Many of Sir Roy's problems must lie where he laid them, before the Royal Aeronautical Society and the Society of British Aircraft Constructors, for further study. The one unifying idea of paper and discussion was that of the need for more and better engineers, and we welcome Viscount Caldecote's intention to take every opportunity of stressing the fact that Great Britain survives by the efforts and excellence of her engineers, and of stressing it particularly where it will do most good—that is, to those who influence the choice of careers by those completing their schooling.

The technical interest of the conference lay in particular in the forecasts made about the new generation of high-performance machines soon to come along. These aircraft, it was suggested, will have structures much more like those found in other engineering fields than previously. Major components may be sculptured from single slabs of metal and not assembled from a multitude of delicate parts by myriads of rivets or specialised bonding materials. Certainly this change in production method would demand huge and costly tools for the initial preparation of the material, but if pressed to its logical conclusion, it promises to eliminate the slow and expensive building up of special jigs and tools for each different aircraft. It is, of course, that latter requirement that makes small runs prohibitively expensive with present techniques. The new genus of machine tools should operate with only rudimentary fixtures to locate the work, and the special-to-type locations, contours and dimensions would be preserved in the director mechanism. Since aerofoils are in many cases designed to theoretical profiles, the machine, it seems, might well be made to generate the surface under the command of a computer capable of evaluating mathematical functions; the cartesian co-ordinates of the aerofoil surface might only be known to the production engineer at a very few points used to confirm the unvarying accuracy of the tool. Instructions for producing arbitrarily designed details, carrying out programmes of drilling, or roughing out masses of metal at high speed, could be stored on punched tape. Such machines, if employed intensively, could result in a reduction of the crippling lead time to produce new aircraft, and also bring the production costs down. These techniques could not be practised by any existing machines, and present a field in which Great Britain could take the lead. In Sir Roy's words, "It is . . . no good talking about these innovations as far-off research possibilities; let us grasp with both hands this opportunity to employ the sort of engineering which has for so long been our birthright."

But the machines required will have to exceed in accuracy, stiffness, responsiveness and size any in existence. A 40,000-ton press, which would take several years to build, would be a starting point. One possibility mooted was that aircraft engineers would design and develop their own machines, and the conference heard of one firm whose special-purpose milling machines had achieved unprecedented metal removal rates in light alloy. While the industry is hobbled by a dearth of mechanical engineers, however, this cannot be considered as a general solution. But the machine tool industry, heavily though it is committed to the manufacture of conventional tools, would undoubtedly be interested could it feel reasonably sure of the existence of a sizeable market for tools of the character here considered. The tool-makers are, of course, entitled to be presented with a clear picture of the job their machines have to do. Co-operation from the electronics manufacturers and, as was suggested at Southampton, those responsible for the machineability—or otherwise—of the material would be needed. The aircraft industry, however, cannot expect the machine tool makers either to design or make such tools quickly unless it can say clearly what it wants and indicate in what quantity it wants them. It is very probably true that the

survival, in recognisable form, of the British aircraft industry, the oldest aircraft industry in the world, depends upon these tools. If so, we do not believe that machine tool builders will accept the view put forward by the staff of one manufacturer in a paper to the conference, that the manufacturers will be content to provide tools to manufacture aircraft well behind the state of contemporary development in other countries. The matter is one not for the aircraft industry alone, nor the machine tool industry alone, to study. A joint effort is required, and it may well be, since the aircraft industry is so heavily dependent on Government orders and the country so dependent on the industry for defence, that the Ministry of Supply should also take a hand.

HUMAN ASPECTS OF REPETITIVE WORK

That breaking down complicated jobs into simple operations which the unskilled or semi-skilled can perform has contributed very greatly to the raising of living standards cannot be disputed. For the high outputs per man hour now enduring could not have been reached in any other way. Nor can it be denied that time and motion study has made large contributions of its own. But the human implications of these methods of heightening production are much less satisfactory, as Winston Clewes points out in a pamphlet recently issued by the Industrial Welfare Society. One of the objects of motion study is that of discovering a series of movements for the doing of a particular task which will encourage high output and induce the least fatigue. But there must always be doubt about its success. For fatigue is a subjective condition. It depends upon the mind. Boredom, dissatisfaction with working conditions, irritation at unexplained delays, dislike of a foreman and a host of other factors can influence the mind to believe that the body is fatigued; and, in the other direction, repetitive work can so drug the mind that, so long as rhythm is maintained, fatigue fails to be noticed. Presumably there is a scientific limit to what the body can endure. But it must vary between individuals and it is very difficult to determine where it lies. It is, for example, notable in athletics how records continue to be broken and how, once a new record is set up lesser athletes find much less difficulty than before in equalling or surpassing the previous record. Who fifty years ago would have believed it possible that a man could run a mile in under four minutes? In fact, the real rate at which men will work is settled not by some scientific limiting fatigue factor but by a subjective assessment under the conditions existing of what is a fair day's work. Nor need it be necessarily assumed that this assessment will be made relative only to the weight of the pay packet. The impression that working men are interested only in that packet may well be a reflection of the fact that there is nothing else that they are allowed to be interested in, that all else, conditions of work and even their movements at work, are settled by the management. But these conditions will, still, subjectively, influence their assessment of what is a fair day's work.

It will, of course, be pointed out that monetary incentives do, in fact, bring about increases of output. What is questioned here is whether they bring about anything comparable with the increase of output that could be attained were certain factors better understood. The adoption of an incentive scheme encourages men to try to raise output. But the level of output eventually attained will be settled not by the detail of the incentive scheme but by a number of other and much more human factors. Recently, for example, there was a strike because one man in a shop was doing, in the eyes of his fellows, much too much work. The conclusion can certainly be drawn that the output of the shop could have been much higher than it was. But for some reason the men were working less hard than they could. Why? Hesitantly some answers can be suggested. Each man may selfishly have feared the loss of his job; or, unselfishly, feared to show up the inefficiency of some of his companions so that they would lose theirs. There may have been suspicion of the management, a fear that labour was to become "sweated." Failure to work harder may have been a consequence of boredom or it may have been that one man working faster than the rest upset the rhythm of the whole. Or, more probably, it may have been a consequence of something else. How much we should like to know! For the attitude of mind revealed is not merely quite common; it is much more probably universal. The difficult concept of what we mean by work comes into this discussion, too. For to men, though not perhaps for women, whose minds are differently constituted, repetitive work is toil, a toil undergone daily not for any satisfaction it can bring but because with the money earned satisfaction can be bought outside the works.

What counts for far more towards high production rates than the adequate breaking down of jobs and the perfection of motion studies is the maintenance within a factory of high morale. That is one of the jobs of management. The prevention of irritating delays, the maintenance of comfortable working conditions, the setting-up of canteens, recreation and social clubs and so on can all contribute to keeping morale high. But it is very dubious whether these activities go far enough. For if everything else is solely the concern of the management the interest of workers will remain centred on the pay packet rather than the work. It is, therefore, held by some firms that the employees themselves should have some responsibility for management, that, in short, democracy should rule in the works, as in politics. Amongst others in this country the Glacier Metal Company, Ltd., and the Aston Chain and Hook Company, Ltd., are working on these lines. Maybe they will be successful; but we confess to a doubt whether such methods will succeed in a mass production factory. For, basically, repetition work is making machines of men. Can democracy compensate for that indignity? There seems to us more to hope from the coming of automation. For an automatic factory would be operated by a comparatively few skilled men responsible for keeping the plant working and able, therefore, to take an interest and a pride in their job. For them, indeed, democracy in the works might have a meaning. For it would affect their most important activities. But would they want it?

100 YEARS AGO

("*THE ENGINEER*," *JANUARY* 11, 1856)

A LIGHT ON THE SMOKE NUISANCE

"The number of schemes propounded for the purpose of 'consuming smoke,' and for the 'prevention of smoke,' renders the task of reviewing them no easy one, and it will scarcely be thought possible to suggest a new plan or a new application of principles already declared; but in many of the propositions before the world the authors seem to have overlooked the very essence of the matter.... It is not the burning of smoke that is needed, but the prevention of smoke by consuming the ingredients of the fuel; and the economy of this can only be proved by the perfect combustion of the gases and the carbon within the furnace, thus rendering the heat generated available for the purpose of making steam. The saving will then equal the previous actual loss. The first point to be considered is—What is combustion?

"Combustion, ordinarily, means the chemical combination of oxygen with a combustible substance at a high temperature; but, strictly speaking, is the development of heat by combination of a combustible and a supporter. It is true that oxygen will unite with such a substance at all temperatures, but perfect combustion may be defined as the chemical combination of a combustible body with the largest measure of oxygen with which it is capable of uniting. Combustibility is not a quality of the combustible by itself, but the union of the combustible with oxygen as the supporter. Neither alone will burn; so, to effect combustion, the combustible body must necessarily unite with a supporter, and in the case of the furnace this supporter is oxygen; and the chemical union of oxygen with the combustible portions of the coal will form one of the chief elements in the development of an antidote to the smoke nuisance."

A Seven Day Journal

A.B.C. Conference on the Unification of Engineering Standards

It is announced by the British Standards Institution that copies are now available in this country of the full report of the A.B.C. Conference which was held in New York in April last, between America, Britain and Canada, on the unification of engineering standards. The object of the conference was to overcome some of the many small but highly important differences which still exist between this country and America in engineering practices, notably screwed fastenings. The seventeen delegates from this country were led by Mr. Stanley Harley, who was, at that time, chairman of the B.S.I. engineering divisional council. For the first time the conference was attended by official observers from all British Commonwealth countries as well as from Canada. It was pointed out by Mr. C. A. Gladman, of Australia, that Australia was at the cross-roads between British and American practices and it was important that there should be some unification of techniques, practice and engineering standards amongst English speaking, inch-using, nations. It was emphasised by the leaders of both the British and the American delegations that the conference was in no sense an effort to set up an English speaking "inch-bloc," to confront countries in the International Organisation for Standardisation which use the metric system. There was no A.B.C.-I.S.O. competition but the work of each organisation naturally dovetailed in with the other. It was decided to bridge the gaps between these conferences by appointing correspondents in each country for each subject of study, and to keep each other informed of domestic progress. The subjects discussed at the conference included threads of various kinds, terminology, surface finish, limits and fits and miniature ball bearings. There was also an informal discussion on gauging.

I.Mech.E. Staff Appointments

The Council of the Institution of Mechanical Engineers has announced the appointment of Mr. K. H. Platt as deputy secretary, and Mr. F. H. Hearn as assistant secretary of the Institution. Mr. Platt, who joined the Institution's staff in November, 1952, has been assistant secretary since May, 1953. He was educated at Shrewsbury School and at the University of Glasgow, where he gained his B.Sc. with first class honours in mechanical engineering in 1930. Mr. Platt received his practical training in Scotland, was subsequently a technical assistant in the drawing-office of James Howden and Co., Ltd., and in 1937 was appointed a lecturer in mechanical engineering at the School of Mines, Treforest. In the following year Mr. Platt went to India as head of the mechanical engineering department of the University of Benares. Mr. Platt served with R.E.M.E. during the second world war, and after demobilisation in November, 1945, was concerned particularly with technical education and apprentice training. For a time he was an inspector in the Ministry of Education, later serving as education officer of The English Electric Company, Ltd., and The Brush Electrical Engineering Company, Ltd. Prior to joining the Institution's staff Mr. Platt was for some months honorary secretary of the East Midlands branch. Mr. Hearn, who has now become assistant secretary, joined the clerical staff of the Institution in 1921. For some years he was the secretary's personal assistant, and since 1932 has been the Institution's accountant, in which position he has been closely associated with the work of the council and its finance committee. Mr. Hearn is a Fellow of the Institute of Company Accountants.

Education Within Industry

The presidential address to the Institute of the Motor Industry was delivered on Thursday, January 5th, by Mr. S. S. Dawes, M.I.Mech.E., who emphasised the importance of technological education if Great Britain was not to be eclipsed by the U.S.S.R and U.S.A. Discussing the Institute's four-year residential diploma course at the College of Technology, Loughborough, the president observed that the industry had not been appropriately represented among the firms financing scholarships for this course. He inferred that businesses had succeeded in making substantial profits by reason of the increased prosperity of the whole industry and the manufacturers' distributive policy, and asked the member organisations to consider their responsibilities other than that of earning a trading surplus. The demand for well-trained administrators would not be satiated by ten times the present output of the course, and their presence was vital to the industry. Mr. Dawes also observed that prices carrying heavy proportions of labour costs were tending to be not competitive in the markets of the world, and that to enhance productivity each man must be free to earn whatever reward his knowledge and ability could command ; his views drew vocal support from the members.

Centenary of the London General Omnibus Company

On Saturday last, there occurred the centenary of the first appearance of "General" buses in London. From 1829, when George Shillibeer ran an "omnibus" between Paddington and the Bank, until the time of the Great Exhibition, there had been a host of competing operators, but in 1855, Messrs. Ordi, Foucaud and Carteret formed, in Paris, where bus services had been known since 1662, the *Compagnie Générale des Omnibus de Londres*, which bought up 600 of the 810 buses running in London. Only twenty-seven vehicles were operated at the beginning of 1856, but the full 600 were acquired during the year, only 567 being needed to continue. In February of that year we recorded that of the seventy-four designs entered for the L.G.O.C. £100 premium competition, many were quite absurd, and others as impracticable ; the winning design proposed to use a tell-tale similar to those used "in Paris, where the conductor is compelled, under fine for neglect, to sound an alarm upon each passenger entering—the member being thus registered." Our comment was that the best way to prevent fraud would be to increase the pay of the men, so as to enlist a respectable class in the service, and, at the same time, to give them some greater relaxation, the working hours being quite excessive, and on Sunday and weekday alike. It was estimated that losses through dishonesty amounted to £25,000 yearly. Next year, we reported of the "corresponding" system of transfer tickets that it was used by 4000 passengers daily, "the principal portion of whom are ladies, the gentler sex having availed themselves readily of so pleasant and easy a method of reaching any place they may wish." On May 12, 1856, a three-horse bus carrying nineteen inside and twenty outside passengers commenced service, while in the next year the company resolved on a plan to establish tramways where the width of the road would admit them without interference with the ordinary traffic. In 1905 the company ordered fifty Büssing motor omnibus chassis from Straker and Squire, and in 1911 ceased to operate horse-drawn vehicles. In 1933 the L.G.O.C., in common with scores of other London transport undertakings, became a part of the London Passenger Transport Board.

Operation of Two New Hydro-Electric Power Stations

The North of Scotland Hydro-Electric Board has brought into operation the Finlarig power station in Perthshire and the 2·4MW power station at Mullardoch, in Inverness-shire, bringing the total generating plant commissioned by the Board during 1955 to 127MW in six power stations. Finlarig generating station is on the shore of Loch Tay and is the station of the Lawers section of the Breadalbane hydro-electric scheme. It accommodates a single horizontal-shaft turbo-alternator set of 30MW capacity, in which the alternator is driven by two twin jet overhung Pelton turbines. The machine operates under a head of water of 1360ft, the highest of any station so far built by the Board. Its annual output will be about 80,000,000 units of electricity. Water to operate the Finlarig power station is stored in Lochan na Lairige, 1620ft above sea level, where a dam is at present under construction. The Mullardoch power station is nearly 90ft underground at the Mullardoch end of the 3¼ miles long tunnel between Loch Mullardoch and Loch Benevean, the two reservoirs of the Affric scheme (see The Engineer, April 11, 18, 25, 1952). Access is by lift. The relatively large turbine drives through bevel and reduction gearing a small asynchronous alternator of 2·4MW capacity. It is estimated that it will produce about 8,000,000 units of electricity per annum.

Dr. F. Sherwood Taylor

We regret to have to record the death of Dr. Frank Sherwood Taylor, which occurred at Crowthorne, Berkshire, on Thursday of last week, January 5th. Dr. Sherwood Taylor, who was fifty-eight, had been director of the Science Museum at South Kensington for the past five years. He was educated at Sherborne School, Lincoln College, Oxford, and University College, London, and for some years in the earlier part of his career taught chemistry in various schools, among them Gresham's and Repton. In 1933 Dr. Sherwood Taylor was appointed assistant lecturer in inorganic chemistry at Queen Mary College, University of London, where he remained for five years. Subsequently, he became curator of the Museum of the History of Science, at Oxford, until, in 1950, as stated above, he was appointed director of the Science Museum. During the period of his administration at South Kensington Dr. Taylor did much to encourage the educational aspects of the museum by the organisation of regular lecture courses. He was also keenly interested in the improvement of the science library. During his career, Dr. Taylor made many contributions to the literature of science and scientific history. He was a past-president of the British Society for the History of Science, a founder member and honorary editor of the Society for the Study of Alchemy and Early Chemistry, and a governor of the Imperial College of Science and Technology.

The Royal Navy in 1955

No. II—(*Concluded from page 9, January 6th*)

Naval Aviation.—Though the Fleet Air Arm still lags far behind the Royal Air Force and the United States Navy, it is now at least a force fully equipped with jet aircraft. Nine squadrons are equipped with "Sea Hawk" day fighters, two have been embarked with "Sea Venom" night fighters, and there are now two squadrons of "Wyvern" airscrew turbine strike aircraft. All these are, however, straight wing sub-sonic machines and urgent priority should be given to replacing them with modern swept wing aircraft worthy of the brilliant pilots of the Fleet Air Arm. A year ago it was noted in these columns that the twin-Avon Supermarine "N113" interceptor—credited with being the fastest and most powerful carrier-borne aircraft in the world—was to be the Navy's new day interceptor, but there is still no news of when it is likely to be in service (Fig. 6). The same applies to the de Havilland "110," which is to replace the "Sea Venom" (Fig. 7). Apart from the announcement last January of a production order, there has been no information of the progress made with this machine. A more urgent requirement is a replacement for the Navy's strike fighter—the "Wyvern"—which is underpowered and unsuitable as a carrier of the latest type of missile. The First Lord has announced that a successor for this aircraft is planned, which of course may mean anything at all. It is, in any event, unlikely to be in service for another four or five years. For anti-submarine operations there are now four twin-Mamba Fairey "Gannet" squadrons available—first rate hunter/killer A/S aircraft with a large endurance and equipped with search radar and sonobuoys. Another and smaller anti-submarine aircraft is the "Seamew," with relatively low landing and take-off speeds and specially designed for operating from escort and other small carriers. It is not yet in squadron service, but first deliveries are apparently intended for Coastal Command and for the R.N.V.R. squadrons. A number of R.N.V.R. squadrons have already been equipped with Supermarine "Attackers" which will, in turn, be replaced by "Sea Hawks" when available. More emphasis is, however, being laid on the anti-submarine than on the fighter function of the R.N.V.R. squadrons and they will eventually have a much greater proportion of "Gannets" and "Seamews" than "Sea Hawks."

There is little doubt that the future of anti-submarine operations from the air lies as much with the helicopter as with fixed-wing aircraft and the Royal Navy has done well to order a number of United States and British helicopters of various types. New possibilities will be opened up when the technique of night and blind flying in these machines has been developed but, apart from intercommunication, life saving and "taxi" duties, it is clear that helicopters will be of the greatest use both for anti-submarine and minesweeping operations. They may indeed prove effective in sweeping types of mines which still present difficulties and danger for even the latest minesweepers. A development of the twin-engined, twin-rotor Bristol "173"—known as the "H.R.12"—is already in production as an A/S reconnaissance helicopter and 100 of these machines have been ordered. It is the intention to develop helicopters with gas turbine engines. The practicability of operating helicopters from merchant ships has been investigated and trials have shown that they can take-off and land-on successfully in moderate weather. In their present state of development, however, there would be difficulty, when operating from merchant ships, in deploying them economically and giving them adequate maintenance. Apart from this the main limitations of existing helicopters are lack of range and speed, the average machine in use having a range of about 400 miles and a cruising speed of under 100 miles an hour. The Royal Navy having vastly increased the operational efficiency of all carriers, large and small, by introducing the steam-operated catapult, the angled deck and the mirror landing aid, has now rounded off these improvements by producing a device known as the "audio airspeed," which indicates aurally to the pilot his approach speed, thus allowing him visual concentration 100 per cent on the carrier's deck. It is interesting to note in this connection that on a normal landing a pilot has hitherto spent on an average over 30 per cent of his time looking at the air speed indicator inside the cockpit. Now, aided by the scientists, the Royal Navy is tackling the chief remaining difficulty in deck landing—the increasingly high approach speed of the latest types of aircraft—by means of boundary layer control. With blown flaps the turbo-jet engines blow air over the wing flaps, which have been lowered to increase the lift, thus reducing the stalling speed by as much as 20 knots.

Fig. 6—The Supermarine "525," from which the "N.113" naval interceptor has been developed, making its first landing on a carrier

The Submarine Situation To-day

Britain now has sixty effective submarines (including four midgets) with five more under construction. Since the war all existing vessels have been equipped with the snort for charging batteries while submerged or proceeding submerged at speeds up to 10 knots. The majority have been streamlined and some have been given extra battery power to hold a submerged speed of up to 17 knots for somewhat less than an hour, when the battery would be exhausted. Under suitable weather conditions, however, the snort can nowadays be detected by radar and 17 knots is no longer an adequate speed for

Fig. 7—The "D.H.110," to replace the "Sea Venom" night fighter

operational requirements submerged. Both the Royal Navy and the United States Navy are therefore developing genuine submarines —vessels which will either normally operate submerged (instead of submerging only when necessary) or will at least have the performance submerged required by a submarine to-day. The U.S. Navy has chosen an atomic plant with an endurance submerged which for practical purposes is limited only by the endurance of the crew, while the Royal Navy, pending the development of cheaper, more efficient and smaller reactors, is trying out—to quote from the Admiralty bulletin—"propulsive machinery of novel design employing hydrogen peroxide."

From official sources it is known that both the U.S. "Nautilus" and the British "Explorer" will be able to maintain a submerged speed of over 20 knots. But while the "Nautilus" can continue this speed for as long as desired, the endurance of the "Explorer" is limited by the amount of hydrogen peroxide carried. The Admiralty is naturally secretive on the subject, but it is interesting to note that in 1944 the Germans ordered 100 general-purpose submarines which were also to have had a hydrogen peroxide power plant. None of them had been completed by the time the war ended, but the Germans anticipated a maximum endurance and speed submerged of 158 miles at 25 knots. In the opinion of many submarine experts these figures should be adequate to meet the essential requirements submerged, which may be summarised as the ability to proceed submerged fast enough and for a sufficiently long period, both to evade anti-submarine vessels and, when faced with enemy aircraft reconnaissance, to intercept a target reported 150 miles distant. The "Nautilus" seems to have given every satisfaction in her trials, for the Americans are to build a flotilla of eight submarines of this type. The Royal Navy has one vessel being built similar to the "Explorer." The main disadvantages of the "Nautilus" are, of course, her immense cost and size. Costing over £18,000,000, she is well over 3000 tons and thus very unhandy submerged and an easy target for asdics. The "Explorer," on the other hand, is a relatively small submarine with an extreme length of 225ft 6in.

Concurrently with the increase in performance of the submarine, however, measures for her detection and location have also vastly improved since the war. Magnetic airborne detection equipment can detect the presence of a submerged submarine from the local change her hull makes to the earth's magnetic field. Her track submerged can be plotted from a battery of sonobuoys fitted with microphones and dropped near her reported position. Another method of detection—particularly when used by helicopters—is the dipping asdic. And there are many methods and missiles nowadays which can be used for her destruction. Indeed, a submarine which continues her attack after detection has a poor chance of escape. The use of high speed when attacking is merely a disadvantage in increasing the hydrophone effect given in the asdic installation of the anti-submarine vessel. On the other hand, provided they do not deliberately come within asdic range of surface vessels, it will be extremely difficult to locate these genuine submarines operating at speeds of over 20 knots at depths of from 200ft to 600ft. They may well attack at long range using homing torpedoes. Alternatively they are even more likely to be used to fire guided missiles with nuclear warheads at shore targets. The Americans already have submarines equipped to launch guided flying bombs. The Soviets might well employ a substantial number of their 500 submarines in this type of operation and in laying mines, operations which require little professional skill or judgment on the part of their commanding officers.

Research and Development. — British scientists and engineers are probably as knowledgeable and as capable as those of any other country in the world, but the extent to which we are able to deploy the results of our researches is necessarily governed by our limited resources of money and material. None the less, the maritime strength of the NATO Powers is continually being increased by British inventive genius. Having very greatly improved the operational efficiency of carriers by the inventions of the angled deck, the steam-operated catapult and the deck landing mirror, the Royal Navy has turned its attention to the maintenance of ships' efficiency under atomic attack.

Pre-wetting—an automatic system for washing down a ship's upperworks—has now been extended to cover the whole ship. This removes the radioactive "fall-out" from an atomic explosion before it can do serious harm to the ship, while the crew remain under cover and continue to control their weapons and con the ship between decks. In these circumstances a large amount of contaminated air would be drawn into the ship through the engine-room and boiler room intakes. Arrangements have therefore been made to work the machinery by remote control, thus enabling a ship to steam away from the area with the machinery spaces unmanned.

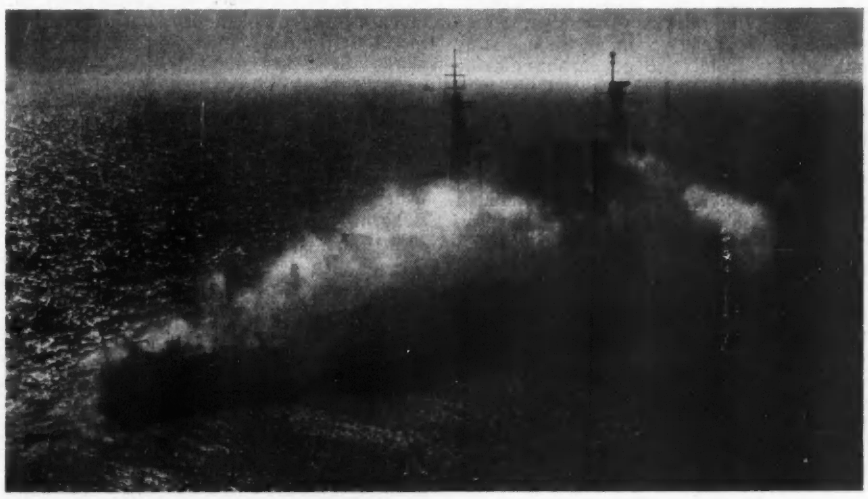


Fig. 9—H.M. Trials Cruiser "Cumberland" being washed down from sprays to keep her free from radioactive particles

A new type of fully automatic medium calibre anti-aircraft gun to provide the inner defence against jet aircraft is also receiving its final tests. When forecasting the construction in the near future of ships with a guided missile anti-aircraft armament to replace our older cruisers, the First Lord announced that a system would be developed "in the years ahead" capable of operating a ship-to-ship guided missile from the same equipment. This presumably refers to a requirement of the distant future—some fifteen to twenty years hence—when, according to experts, the bomber will have been driven out of the sky by the anti-aircraft guided missile. Meanwhile the radar-controlled gun seems adequate for a cruiser's escorting and trade protection duties as long as it provides the main armament of potential enemy cruisers.

Fig. 8—The Short "Seamew" A/S aircraft landing on H.M.S. "Bulwark"

Escape and Survival

The new policy of free ascents from a sunken submarine was fully vindicated last year, when successful ascents were made from H.M.S. "Solent" resting on the bottom of Loch Ewe at 128ft. The escapers wore no Davis apparatus (D.S.E.A.), which helps

to reduce the chances of CO_2 poisoning and "bends," but is likely to result in oxygen poisoning. In existing submarines the crew breathe a mixture of 40 per cent oxygen and 60 per cent nitrogen—from bottles installed at each end of the submarine—while the compartment is being flooded to equalise the pressure and thus enable the hatch to be opened. New submarines will, however, be fitted with a one-man escape chamber forward and aft, thus eliminating the need for flooding and for breathing foul air under pressure. The chamber will be flooded and drained and the hatch opened and closed again by the other members of the crew in the compartment. Much progress has recently been made in the design of life-saving rafts and life jackets. Rafts are now built in two sizes—for twenty men and for eight men—the buoyancy chamber, which resembles a car tyre inner tube, being inflated by a mixture of carbon dioxide and oxygen contained in bottles. A tent with two skins, with an air gap for insulation purposes, can be erected in tropical climates and a small solar still is provided for distilling salt water. The new life jackets are made of two-ply rubberised cotton inflated by means of a spring-loaded non-return valve, and enable an unconscious man to float with his head supported clear of the water. Following the adoption of the scoop net for saving life, helicopters are now to be provided with a transport stretcher. This will enable a patient to be lifted off the deck of a ship by helicopter and transferred to base or to another ship for medical attention without being removed from the stretcher. The invention clearly has application to Army and civil defence work.

Dockyards and Maintenance

A grant of £340,500,000 was approved for the Navy Estimates during the current year, £12,500,000 less than for 1954/55. Of this sum £5,500,000 is being expended on ordinary repairs and maintenance. The policy for the maintenance of the Reserve Fleet has now been radically changed. Instead of maintaining a large number of ships in reserve in various states of readiness, an increasing proportion of the Reserve Fleet is in future to be kept at the highest standard of readiness, thus ensuring that as many ships as possible will be ready for manning and taking to sea at the outbreak of war. This will require special measures, and their maintenance will be carried out principally in private shipyards. The Royal Dockyards will consequently be able to devote a higher percentage of their effort to the upkeep of the seagoing fleet. The conditions arising from a nuclear war will also necessitate the Navy being less dependent on shore establishments for maintenance and supply, and the Admiralty has recently set up a committee to review the existing supporting and supply organisation of the fleet in the light of the vulnerability of shore establishments.

Many frigates and other ships of the reserve fleet are now laid up in commercial harbours and maintained largely by civilian labour after being dehumidified. Corrosion of their hulls is prevented by an adequate coating of paint and other materials, supplemented by cathodic protection—passing a current to the hull from external anodes. A successful test was carried out last year to determine the efficacy of dehumidification and other arrangements for the preservation of these vessels. The frigate "Eglinton" was commissioned with a crew from the three home ports and, after embarking all naval and other stores, was brought forward and taken to sea for trials without difficulties or delays of any kind. The majority of the large number of small inshore minesweepers built under the rearmament programme have necessarily to go into reserve. These vessels are eventually to be laid up ashore under cover, but pending the provision of this accommodation they are being fitted with removable wooden awnings to protect the wooden parts of the ship against shrinkage and dry rot and her deck fittings and instruments against corrosion. The effect is to give them a "Noah's Ark" appearance. All new small vessels go first to H.M.S. "Diligence," the Navy's small craft base at Hythe, for naval trials.

There has been a narrowing of the gap between dockyard and contract costs in converting destroyers to frigates. A year ago contractors' costs were sometimes as much as 50 per cent higher, but the cost of the latest (limited) conversion of destroyers works out at £445,000 in a dockyard compared with an estimate of £630,000 by contract. In the light of changing circumstances, a new policy has been adopted for the maintenance of weapons The gunnery branch which, for some years, has been concerned with guided weapons, has now taken over airborne gunnery in all its forms, including rockets and bombs. Atomic weapons are also to be its responsibility. The torpedo anti-submarine branch has similarly been made responsible for all weapons which function under water. The first of the three replenishment tankers launched in 1954, the R.F.A. "Tidereach," has now been accepted for naval service. These tankers are fast ships of over 18 knots and of 26,000 tons. They carry 15,000 tons of fuel, which can be divided into separate categories, all capable of being discharged at an extremely high rate to ships on either beam or astern and while steaming at high speed. In June last the gunboat "Grey Goose" was commissioned, after conversion to a floating test bed for service in the Trials Squadron at Gosport. She has been fitted with two experimental Rolls-Royce "R.M.60" marine gas turbine engines of advanced design, transmitting their power through Rotol controllable pitch propellers, which eliminate the use of reverse gearing. Two similar engines have been purchased by the United States Navy for evaluation. Experience has shown that paddle-driven tugs are the most suitable for moving large warships in dockyard basins and the Admiralty is ordering seven diesel-electric paddle tugs with hinged masts, squat funnels and a raked back stem to enable them to operate under the overhanging sides of aircraft carriers. A new 27ft seaboat has been designed to perform the triple function of a motor seaboat for rescue work, a sailing boat for regattas and a pulling boat for recreational purposes and regattas. When not required, the lightweight air-cooled diesel engine and its fittings can be detached in half-an-hour. As a motor boat it has a speed of 6 knots and endurance of ten hours.

A milestone in the Admiralty's long-term programme for the modernisation of our naval barracks was reached in July when a new building for the accommodation of 624 chief and petty officers was opened at Devonport by the First Lord. It was planned on the lines of a hotel, each petty officer having a cabin fitted with hot and cold water, and cost about £750,000 to build. Good progress is likewise being made under the Armed Forces Housing (Loans) Bill with the building of houses and flats for officers and men at the home ports and it is expected that by 1960 some 4500 additional married quarters will have been constructed. Many changes have also been made recently in uniforms. Jumpers can now be put on without pulling them over the head and trousers are to have side pockets with zip fasteners. Caps will have easily cleaned white plastic tops; and light footwear with non-skid soles are now available for engine-room ratings.

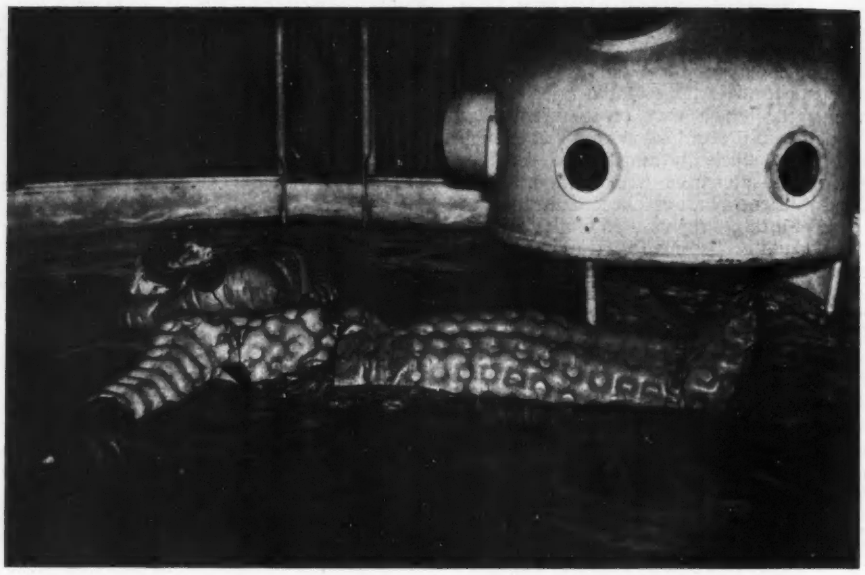


Fig. 10—Demonstration of escape from one-man chamber to be fitted to new submarines. Instead of D.S.E.A. the escaper wears a life jacket and immersion suit equipped with identification light

Personnel.—Since 1837, when the engineering branch of the Royal Navy first became organised as an integral part of the naval service, the status and prospects of engineer officers have been the cause of never ending controversy and committees of enquiry. Last March the First Lord announced two revolutionary changes in the officer structure, the combined effect of which has solved the problem once and for all, though this important fact received little notice when the changes were subsequently discussed in Parliament. It is now no longer possible to provide the necessary number of executive commanders and captains with the sea-going experience

required for higher operational appointments, and officers promoted to those ranks are in future to be promoted either to a "Post List" or to a "General List" (commonly called "wet" and "dry" lists). The former will be eligible for sea-going commands; the latter will not, but will be eligible for command of shore establishments and for staff and administration duties. Both, however, will have equal opportunities for promotion, including promotion to the Flag List. At the same time the use of the suffixes (E), (L) and (S) and the wearing of distinctive lace by non-executive officers have been discontinued (except for medical and other "Geneva Convention" officers). Marks of respect (the parading of guards and bands, the flying of flags and pennants, &c.), are also now the same for non-executive as for executive officers, though "Piping the side" will necessarily be restricted to officers in command of sea-going ships and squadrons. The Admiralty have still under consideration the consequential details of the scheme, but there seems no good reason why an officer of the engineering or electrical branch should not in future sit on the Board. Apart from this point, however, the new officer structure has eliminated any possible difference between the status and prospects of the executive officer on the general list and of the engineer officer. Both can look forward to commanding H.M. shore establishments and non-sea-going ships and to promotion to flag rank. Both also now wear precisely the same uniform and are entitled to the same ceremonial and marks of respect. The titles of ratings of the engineering and electrical branches have also been changed to indicate more clearly the kind of work they do. The term "engineering mechanic," for example, now replaces the word "stoker"—a stoker becomes an "engineering mechanic 2nd class." Similarly an "electrician's mate 1st class" becomes an "electrical mechanic 1st class." The first cadets joining the Royal Navy under the new 18-year-age scheme of common entry went to Dartmouth in May last and it is interesting to note that the first competition for scholarship cadets (to enable suitable lads aged 16 to remain at school) produced no less than 284 candidates for 25 vacancies. After joining the cadets spend two terms wholly ashore and then go to sea for one term in the training squadron, based on the River Dart, consisting of a destroyer, two frigates and two minesweepers. They will also return to the squadron for practical training from time to time during their period at the College as midshipmen.

Vote A for 1955–56 provides for a maximum strength of 133,000, or 6000 less than the previous year. Unfortunately, there has been a further decline in regular recruiting—from 11,000 in 1951–52 to 8000 in 1954–55. And this decline comes at a time when large numbers of special servicemen (seven years' active and five years' reserve), recruited shortly after the war, are leaving. It was hoped that the 1954 pay increases would induce many of these men to remain for at least another five years, but the response has been disappointing and thus there is now a serious shortage of long-service men on whom the Navy depends for the majority of supervisory ratings. There has, however, been a slight increase in the number of twelve-year men re-engaging for pension—some 40 per cent now re-engage—but owing to the absence of regular recruiting during the war the number eligible to re-engage is exceptionally small (only 1750 during the current year). About 5000 National Servicemen are now being entered annually to make up for the fall in regular recruiting, but this number is too large in view of the disproportionate demand on training resources in relation to the period of effective service. To reduce the number of men "in the pipeline," air transport is now being used on a large scale: "Hermes" aircraft in November flew out to Singapore a completely new crew for H.M.S. "Newcastle" and took back the old crew to England. With so many special servicemen leaving, the Royal Fleet Reserve—a fully trained Reserve immediately available in war—has reached a total of 26,000. The strength of the Royal Naval Reserve—recruited from the Merchant Navy—is now about 4780 officers and men. This number, however, includes officers of the newly formed Air Branch of this Reserve who are professional pilots employed by firms engaged in Admiralty work. The Patrol Section of the Reserve is short of officer recruits, but there has been an increase in the number of seamen as the result of many young fishermen joining. (Their National Service is deferred while so serving.) Recruiting for the R.N. Volunteer Reserve (recruited from civilians) is also satisfactory and its strength is now 3980 officers and 10,430 ratings. Large numbers of young officers are now joining on completion of their full-time National Service and the new List II A with a reduced training commitment is also attracting officer recruits. Each Volunteer Reserve division is now equipped with the latest type of coastal minesweeper for practical training and cruising, and the Force was highly honoured when two of these little ships, manned entirely by the R.N.V.R., were privileged on two occasions to escort the "Britannia" with H.M. The Queen on board. The courses for Merchant Navy officers and men which are held at various commercial ports have recently been revised to include instruction in atomic, bacteriological and chemical warfare.

Exercises and Operations

The Royal Navy has been taking an increasing share in operations against the Malayan terrorists, blasting their camps, disrupting their supply routes and keeping them constantly on the move. Apart from these warlike activities and maintaining patrols off the Korean coasts, H.M. ships on all stations have used every opportunity to carry out normal fleet and squadron exercises and practices, in many of which ships of the other Dominion or NATO Navies have taken part. All NATO Navies now have a common set of signal books and all exercises have the same object—to increase the efficiency of each individual ship and aircraft and the ability of the NATO countries' navies to co-operate effectively together in the vital task of defending the sea communications. For the first time since the war, ships of the Royal Navy and of the Yugoslav Navy co-operated in a fortnight's practices in the Adriatic. Special attention has been given in the major exercises to the effects of atomic attack. Task Forces, convoys and replenishment groups have been practised in taking up suitable dispositions in the vicinity of an air or underwater atomic burst and in the internal protective measures that can be taken by individual ships to minimise casualties from flak and radiation. Following a similar arrangement made with the Australian Naval Board two or three years ago, a squadron of three submarines of the Royal Navy is now based at Halifax to provide vessels for the anti-submarine training of the Royal Canadian Navy.

British Railways in 1955

LAST year marked the beginning of a period of outstanding interest on British Railways, for the £1200 million plan announced by the British Transport Commission gave some indications of the extensive changes it is proposed to make to reorganise and modernise the rail transport services of this country. Under this plan, which is to be carried out over the next fifteen years, steam traction is to be replaced by electric and diesel traction, improvements are to be made in tracks and signalling to permit speeds up to 100 m.p.h. on main lines, and goods handling facilities and stock are to be improved. An outline of the plan was given in our issue of January 28th last, and some of its engineering implications were discussed in the issues of February 18th and 25th.

Initial interest naturally turns towards motive power and doubtless, as a result of the plans, 1955 will go down in history as marking the first stage in the end of the steam traction era so far as this country is concerned; for when announcing its plans the Commission indicated that the construction of steam locomotives would cease in 1956. All steam locomotives will eventually be replaced by diesel and electric traction, with diesel locomotives probably being used in many cases as an interim measure before complete electrification on some main lines. Also planned is the extensive introduction of multiple-unit diesel trains in city-to-city express services, and on secondary and suburban services.

Diesel Locomotives

As a first step in introducing 2500 main line diesel locomotives, at a cost of some £125 million, the Commission has already placed orders, valued at nearly £10,000,000, for 130 diesel-electric and eleven diesel-hydraulic main line locomotives with private manufacturers.

At the same time orders were also placed for thirty power units which will be installed in locomotives to be built in the railways' own workshops. These locomotives will be used for a comprehensive series of trials before any further orders are placed in connection with the main scheme.

The diesel locomotives to be used in the trials will be of three main types: type "A" of 600–800 h.p.; type "B" of 1000–1250 h.p.; and type "C" of 2000 h.p. and over. Under the contracts which have been placed for the locomotives, the English Electric Company, Ltd., will build twenty type "A," ten type "B" (with "Deltic" engines), and ten type "C" locomotives. The North British Locomotive Company, Ltd., has received orders for ten type "A" (with Davey Paxman engines and G.E.C. transmission equipment); sixteen type "B" (all with M.A.N. design engines, ten having G.E.C. and six Voith hydraulic transmission equipment); and five class "C" (with M.A.N. engines and Voith hydraulic transmission). The British Thomson-Houston Company, Ltd., will supply ten class "A" locomotives (with Davey Paxman engines). Twenty class "B" locomotives to be built by the Metropolitan-Vickers Electrical Company, Ltd., will have Crossley engines, and twenty class "B" locomotives to be supplied by Brush Bagnall Traction, Ltd., will have Mirrlees engines. A further twenty class "B" locomotives to be built by the Birming-

ham Railway Carriage and Wagon Company, Ltd., will have Sulzer engines and Crompton Parkinson transmission. All thirty of the sets of power units which have been ordered for the railway-built locomotives will use Sulzer engines, the twenty equipments for class "B" locomotives having B.T.H. transmission equipment, and the ten for class "C" locomotives Crompton Parkinson transmission equipment. In addition to the eleven diesel-hydraulic locomotives which are to be built under the main scheme, three 2000 h.p. diesel-hydraulic units are also to be built at the Swindon works of the Western Region. These railway-built locomotives will have Maybach engines and Mekydro hydraulic transmission, and they will be of generally similar design to the locomotives which are already in service on the German Federal Railway, with modifications to suit them to British lines.

In inviting the firms to tender for these locomotives the Commission issued a specification of its requirements in general terms. The very general nature of these specifications will enable manufacturers to introduce their own ideas and special design features in a way which should prove beneficial, from the aspect of long-range testing, both to the makers themselves and to British Railways. Up to the present only brief particulars of the locomotives they propose to build have been given by some of the makers, but during the next year or so there will be some interesting designs developed and valuable data made available as a result of the trials. In this connection it is interesting to note that a new test house for diesel locomotives is to be built at Derby. This house will be equipped for testing two locomotives simultaneously and cater for all types from 350 h.p. to over 2000 h.p.

A very close interest is being shown in diesel traction by many countries overseas, and although the proposed trials are primarily the concern of British Railways their results may well have far-reaching effects on the future of the British locomotive industry. This branch of industry has for long suffered from the lack of full-scale service trial facilities for its locomotives at home and it will now be able to prove to the full the developments it has made in diesel traction. Also for many years private locomotive manufacturers in this country have had to rely upon orders from overseas owing to the British Railways' policy of building its own locomotives, and the receipt of orders for the trial locomotives has been very encouraging to the industry. Not only will the orders be particularly welcome to those firms changing over from steam to diesel locomotive construction, but large-scale trials under controlled conditions in this country will provide them with valuable data for developing new and improved designs.

Multiple-Unit Diesel Trains

A particularly important part of the traction side of the modernisation plan will be the extensive introduction of multiple-unit diesel trains, and it is estimated that nearly 5000 multiple-unit diesel vehicles can be employed on these services to replace steam traction. Under the 1955-56 programme provision was made to introduce 1000 vehicles for the further replacement of steam passenger services by multiple-unit diesel trains. In this connection orders were placed with British United Traction, Ltd., for 848 sets of running units for twin-engined power cars and 443 sets of trailer car equipment.

The running units, designed by British United Traction, Ltd., specifically for multi-engined railcars, consist of engines, gearboxes, final drives and controls. They can be mounted under existing passenger rolling stock to convert them to diesel operation, or they can be incorporated in new coaches which are now being built. Two kinds of diesel engines will be supplied, each interchangeable with each other. They are horizontal engines, the B.U.T. "A" type of 11·3 litre capacity and the "L" type of 11·1 litre capacity, each developing 150 h.p. at 1800 r.p.m.

On a power car two horizontal engines are mounted practically nose to nose under the floor. One engine drives the inside axle of the front bogie, and in a similar manner the other drives the inside axle of the rear bogie. Equipment for each power car, therefore, comprises two diesel engine driving assemblies, each complete with a fluid coupling, driving shaft with a freewheel incorporated, electro-pneumatically-operated four-speed epicyclic gearbox, and a double-reduction final drive. Up to eight cars (four power cars and four trailer cars) or even more, can be coupled together and controlled by one driver.

Electrification

In addition to suburban electrification schemes costing £40,000,000 and extensions to electrification on the Southern Region costing some £25,000,000, the modernisation plan stated that two major trunk routes and one of lower traffic density were also to be electrified. Under these major schemes the main line from King's Cross to Doncaster, Leeds and (possibly) York, and the main line from Euston to Birmingham, Crewe, Liverpool and Manchester will be electrified. The subsidiary scheme will consist of the extension of the existing electrification from Liverpool Street to Ipswich and include the Clacton, Harwich and Felixstowe branches. The estimated cost of the fixed installations for these three large electrifications is £125 million, and some 1100 electric main line locomotives costing about £60,000,000 will also be required. No details have as yet been issued in connection with the electric locomotives it is proposed to use in connection with these schemes.

When announcing the placing of the contracts for the diesel locomotives, the British Transport Commission stated that it had under review its future policy for the manufacture and repair of diesel and electric locomotives. Already training schemes have been started at some of the main railway workshops to prepare staff for handling the new forms of traction, and doubtless a bias will be given towards diesel and electrical work under the apprentices' training schemes. But if the conversion from steam is to take place within the stated fifteen years, and the railways propose to handle all repair and maintenance work, it will call for a considerable amount of workshop reorganisation and training. A further complication will be that in many cases normal maintenance and repair work will be required on the steam locomotives remaining in service during the interim period. Doubtless these problems will be overcome, but it is evident that during the transition period British Railways will have to rely to a large extent upon the help and goodwill of private locomotive manufacturers.

Constructional Work

For the proposed modernisation and electrification a vast amount of work will be involved on the civil engineering side, and here the railways will face many difficulties in maintaining normal services with major constructional works in hand. As indicated in the section on railway work in the Tabular Summary of Civil Engineering Contracts with our issue of December 23rd last, some contracts have already been placed in connection with the modernisation plans.

An important piece of engineering work completed in 1955 was the reconstruction of Potters Bar Station on the Eastern Region of British Railways to provide four tracks in place of the former two tracks. This is part of the main scheme to remove a long-standing bottleneck on the east coast route to Scotland by providing four tracks between New Barnet and Potters Bar. The second part of the scheme, which has been started, involves the construction of three new double-track tunnels at a cost of £2,750,000 to the south of the station.

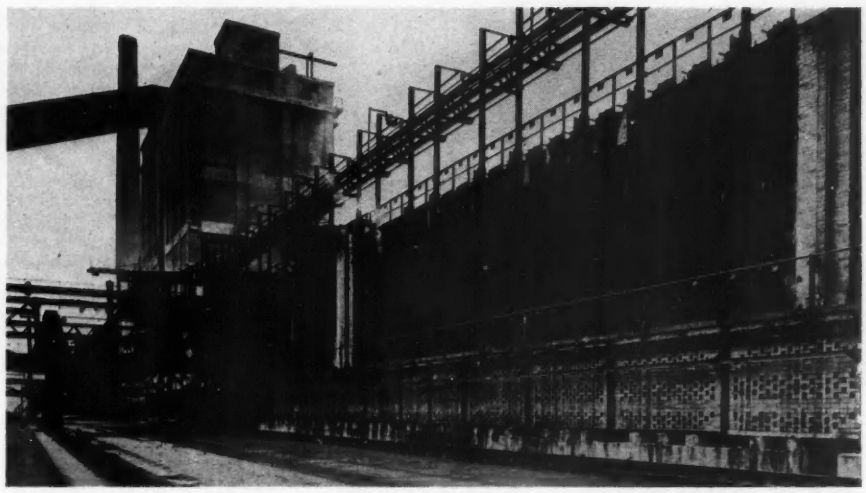
Large sums of money are being spent on the improvement of marshalling yards and goods depots, which form such an important link in the efficient and speedy handling of goods traffic. Improvement works are already in hand or planned at Ripple Lane, near Barking, at a cost of some £1,800,000; Temple Mills, Stratford, at a cost of over £2,500,000; Colwick, costing £1,750,000; Millerhill, near Edinburgh, costing nearly £3,000,000; Port Talbot, at a cost of £1,500,000, and two schemes at Perth and Craiglockhart in the Scottish Region, which will cost together some £1,500,000.

During the past year steady progress was made in the construction of the large new marshalling yard in the Scottish Region, near Thornton, Fife, which when completed is expected to be one of the most modern yards in Europe. This yard, which will cost some £1,350,000, is intended to deal with the large increase in output brought about by development work which is being carried out in the Fife coalfield, and the yard is expected eventually to deal with some 3000 wagons a day. It will have six reception sidings with a hump engine rounding line arranged in tandem with thirty-five through sorting sidings. The control, route selection and other equipment to be installed is of particular interest: the required leaving speed of wagons from the primary and secondary retarders is selected by an operator in the control tower in accordance with the space remaining in the sorting sidings. Radar will be used in the calculation of the speed of wagons entering the retarders, and this information, together with that from a weight detector, which discriminates between heavy and light wagons, is used to determine the speed finally established by the action of the retarders.

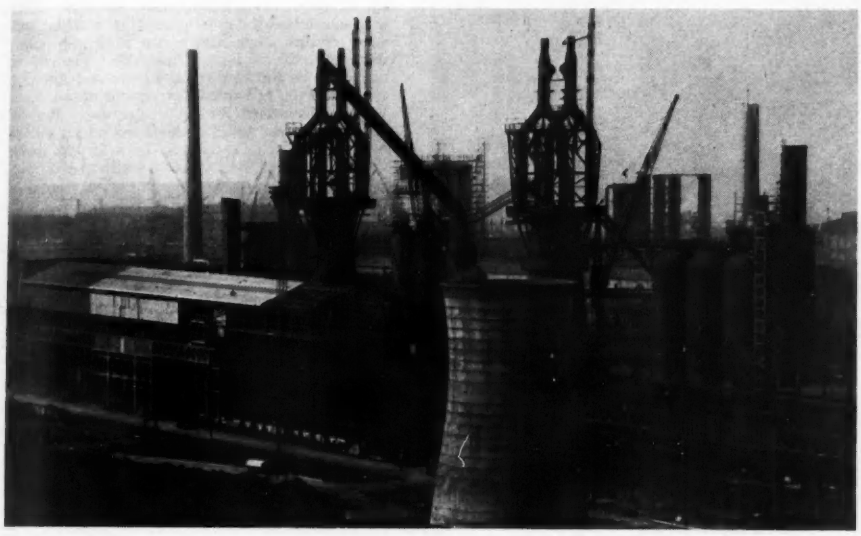
A number of station improvement and reconstruction schemes are already in hand and planned, and one of importance started during 1955 was the reconstruction of Cannon Street Station at a cost of £1,250,000. This scheme, which will take some eighteen months to complete, involves the lengthening of the platforms to take ten-car electric trains, extension of the concourse and rebuilding of adjoining premises.

Course in Production Planning and Control.—The Institute for Engineering Production, Birmingham, has announced particulars of a specialist course in production planning and control, which will last from January 16th until March 30th. The number of members for this course is limited to "about five," and the programme includes two periods (at the beginning and the end) each of three weeks at the Institute's headquarters at Edgbaston, with the middle four weeks of the course spent with the firms from which the members are drawn.

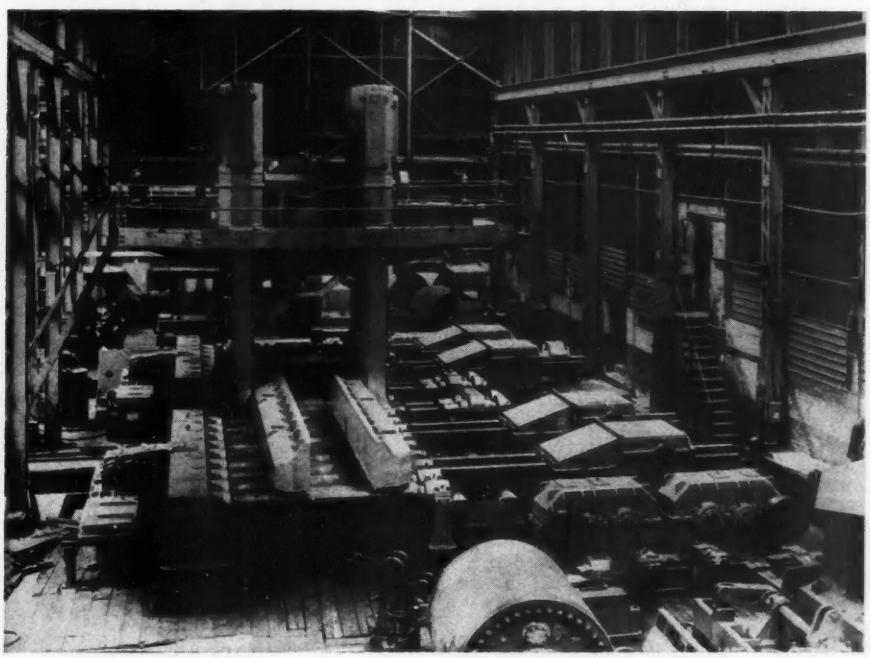
IRON AND STEEL WORKS



In September, The Stanton Ironworks Company, Ltd., opened an extension to its coke oven plant at Hallam Fields, Ilkeston. The original plant, which was built in 1939, consists of forty-one W-D Becker combination regenerative ovens, designed to carbonise 860 tons of coal a day. The extension comprises a battery of forty-four W-D Becker ovens, which are 40ft 8in long between doors, 12ft 6in high and 16in wide, with a taper of 2in. The oven chimneys are 250ft high. Both the old and the new coke ovens are heated with blast-furnace gas. The daily carbonising capacity of the two batteries is 1900 tons of coal. This illustration shows the pusher side of the ovens. The scheme also involved the installation of new gas purification, drying and boosting plants



Throughout last year there was continued progress with the third stage of the development programme of Dorman Long and Co., Ltd. This third stage includes the erection of a combined universal beam and heavy section mill on the Lackenby site, the installation of a medium section mill and a blooming mill at the Cleveland works, a new battery of coke ovens at South Bank, and the building of two new blast-furnaces at Clay Lane. Here we illustrate the blast-furnaces, which have a hearth diameter of 27ft 6in. When they are completed four small blast-furnaces are to be dismantled at the Cleveland works. The new furnaces and the coke ovens will come into production during the summer; they will increase the company's coal carbonising capacity to 2,400,000 tons a year and will add 286,000 tons annually to the basic iron-making resources

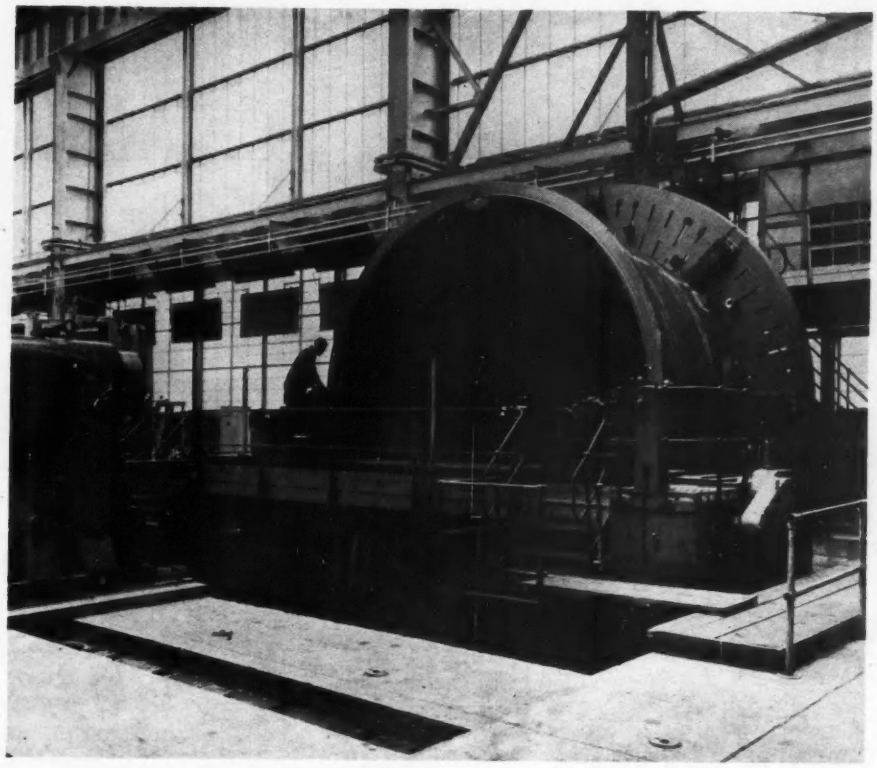


This illustration shows the 34in two-high blooming and slabbing mill which has been built by Brightside Foundry and Engineering Company, Ltd., for the Karabuk Iron and Steel Works, in Turkey. The Brightside Company was responsible for the design and manufacture of all the mechanical section of the plant. The mill, which is now being erected at Karabuk, will roll ingots of 3 tons, each 20½in mean square, for the production of blooms, or 35in by 12in ingots for the production of slabs. The bloom sizes will be from 12in square maximum to 6in square minimum and slabs will be rolled up to 30in wide and 5in thick. The mill train has 36in diameter rolls, 84in long in the barrel. They are driven through universal spindles and a 41½in centres pinion housing from a d.c. reversing motor having a working peak of 14,000 h.p. at 60 r.p.m. and a cut-out peak of 16,100 h.p. at the same speed. The speed of the mill is 0/60/150 r.p.m.

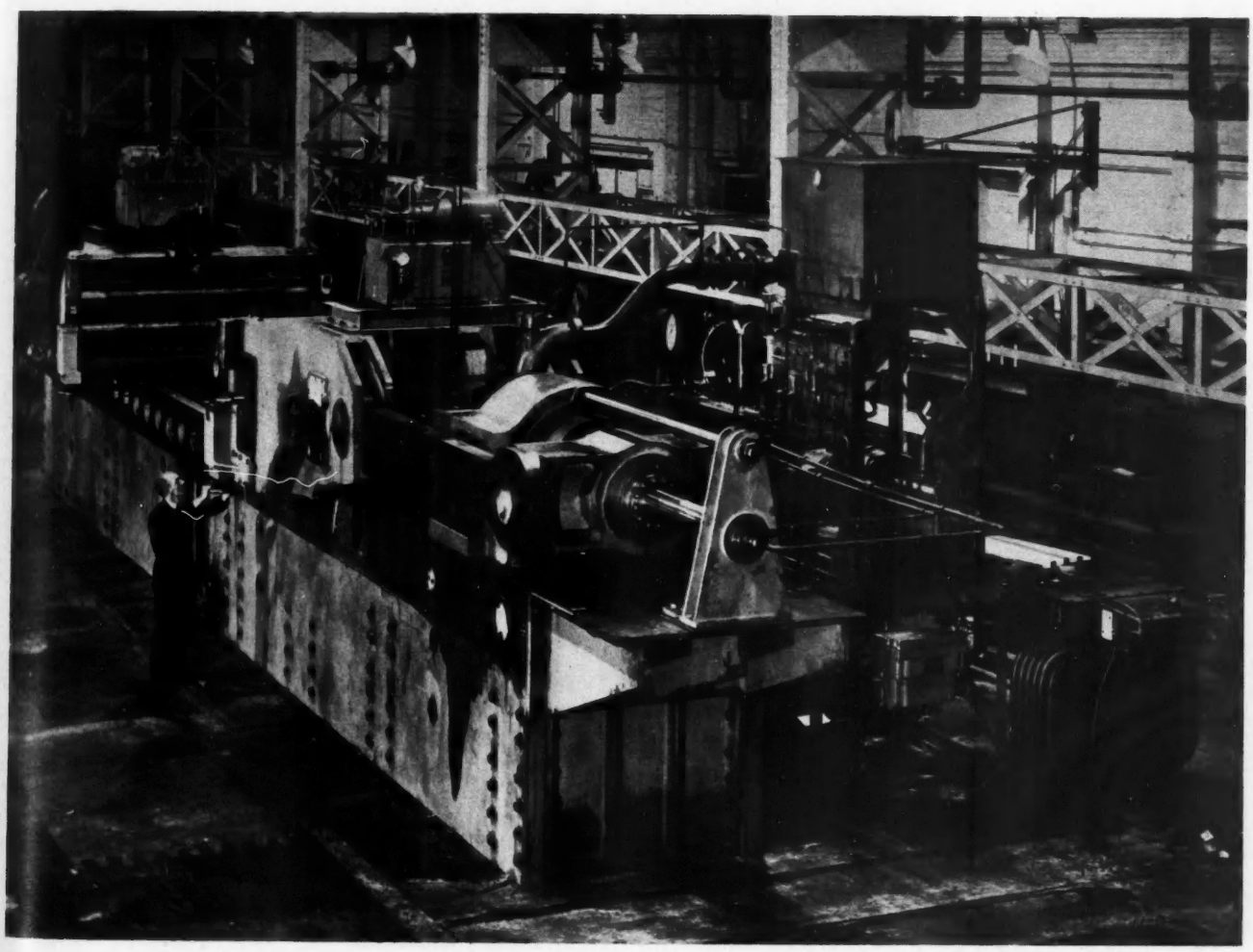
LARGE BRITISH MACHINE TOOLS OF 1955

Among the large machine tools completed during the past year in this country are the vertical boring and turning mill to be seen on the left and the open-side plano-milling machine illustrated below. The vertical boring and turning mill, built by George Richards and Co., Ltd., has a maximum swing of 25ft 3in and the maximum height under the tool holders is 13ft. Its 22ft diameter table is driven by a 120 h.p. variable-speed d.c. motor and is capable of taking work weighing up to 90 tons. The tool bars of the two counterbalanced vertical heads mounted on the cross slide saddles have a down feed of 8ft, and can be swivelled up to 30 deg. on either side. Table speeds from 0·33 to 9 r.p.m. are available and each tool head has sixteen feed rates from 0·007in to 0·75in per revolution for horizontal, vertical and angular motions. The plano-milling machine was built by Kendall and Gent, Ltd., for the Dominion Bridge Company of Canada, and it weighs some 200 tons. Work weighing up to 40 tons can be accommodated on the table, which has a working surface 45ft long by 7ft wide. Two 3½in spindle machining heads are mounted on the cross arm of the machine, and when vertical face cutters are used they admit work up to 6ft 6in high on the table. The table is carried on an 84ft long bed and its normal operating speeds of from 1½in to 24in per minute are increased to 150in per minute for rapid traversing. Each of the two vertical and the single horizontal milling heads is driven independently by a 25 h.p. motor and has sixteen spindle speeds from 16 to 300 r.p.m.

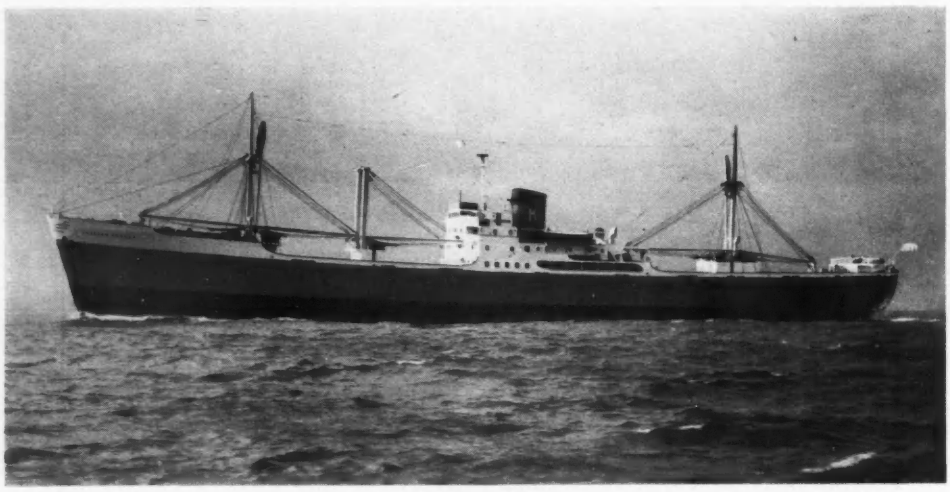
LARGE BRITISH MACHINE TOOLS OF 1955



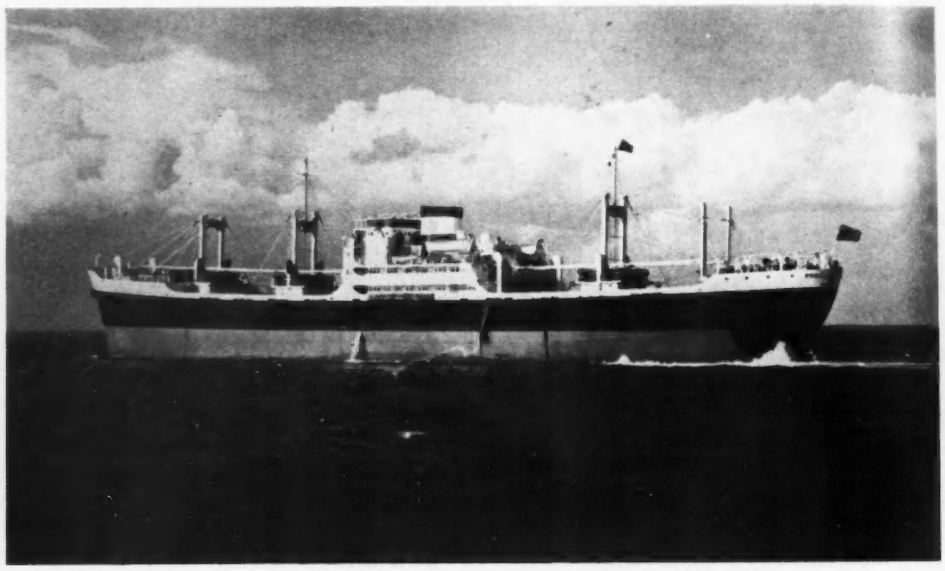
The lathe on the right was designed and built by the Power-Gas Corporation, Ltd., to suit the special requirements of one of the firm's new shops, where particularly large parts for chemical plant, blast furnaces and other heavy industrial equipment have to be machined. This lathe is capable of swinging work 34ft diameter up to a 2ft depth from the face-plate, 24ft diameter between 29ft 6in centres, or 11ft 9in diameter between 50ft centres. Work weighing up to 30 tons can be carried by the face-plate providing its centre of gravity is not more than 7ft from the plate, and the maximum load which can be handled between centres is between 50 tons and 60 tons. Machining can be performed up to some 12ft from the face-plate without the use of centre support for the work. A plate stretching machine designed to exert a maximum pull of 800 tons made by Joshua Bigwood and Son, Ltd., is illustrated below. This machine was built for a firm in Norway and is believed to be the largest of its kind yet made and installed in Europe. It has an effective stroke of 3ft and its movable grip head can be adjusted along the frame to enable sheets from 6ft to 26ft 3in long and up to 7ft 6in wide to be handled



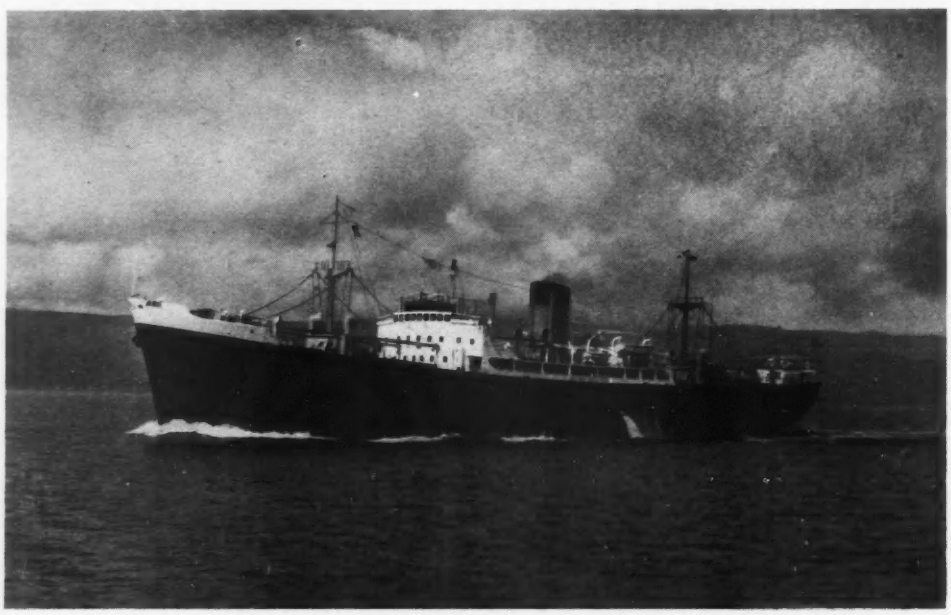
STEAM AND OIL ENGINED CARGO SHIPS



Swan, Hunter and Wigham Richardson completed at the Neptune works the motorship "Capetan Carras," which carries a deadweight of 13,320 tons on a draught of 30ft 7½in. The principal dimensions of the ship, which was built to the order of the Tramp Chartering Corporation of Panama, are: Length between perpendiculars, 450ft; breadth moulded, 62ft, and depth moulded to shelter deck, 40ft 4in. One 30-ton derrick, one 20-ton derrick and ten 5-ton derricks powered by electric winches serve five cargo holds. Three 180kW diesel-driven generators provide electrical power for deck and auxiliary machinery, while the propelling machinery consists of a five-cylinder Swan Hunter-Doxford oil engine of 5500 b.h.p. at 115 r.p.m.

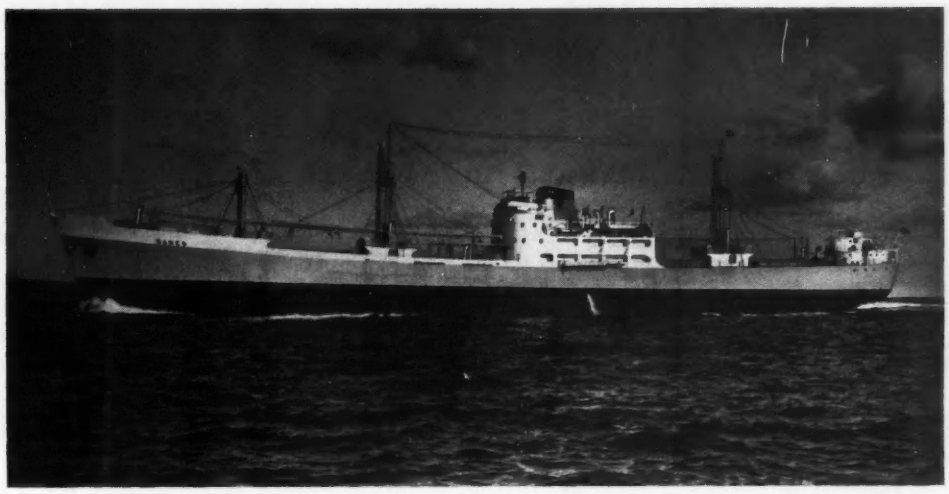


Northern Steamships, Ltd., of Johannesburg, took delivery of the M.V. "President Kruger" from the Furness Shipbuilding Company, Ltd., and the ship of closed 'tween deck design, has a length overall of 467ft 3in, a breadth moulded of 59ft, a depth moulded to upper deck of 39ft 2in, a total capacity of 614,021 cubic feet, and carries a deadweight of 11,165 tons on a Lloyd's summer draught of 27ft 9¼in. The cargo is carried in five clear holds and is handled by fifteen derricks operated by twelve 5-ton electric winches. Electric power is provided by one steam and two diesel-driven generators each of 150kW, and the ship is propelled by a Hawthorn-Doxford opposed-piston, single-acting, two-stroke oil engine having four cylinders of 670mm diameter by 2320mm combined stroke and a brake horsepower of 4400 at 115 r.p.m. Two vertical boilers supply steam for auxiliaries

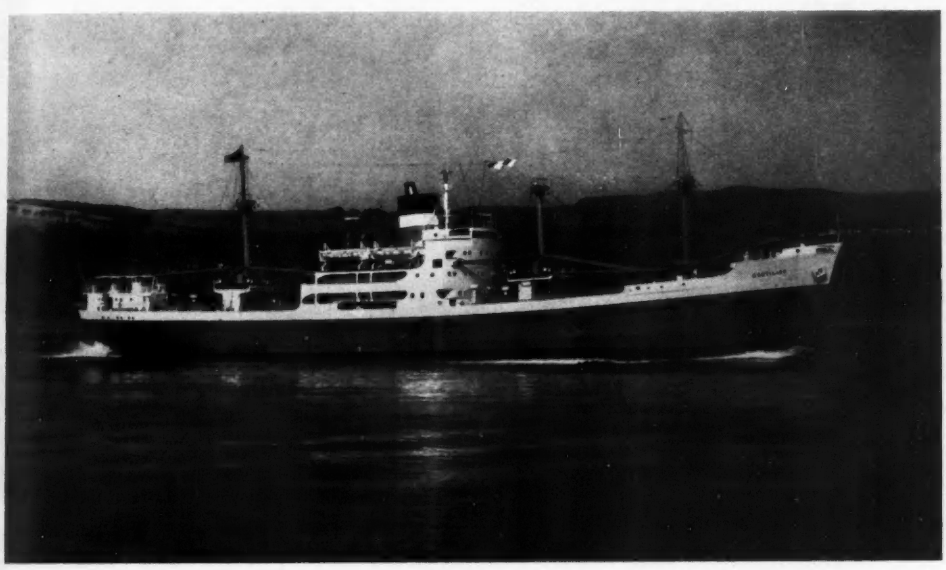


The 9500 tons deadweight cargo ship "Baron Glenconner," was built by the Caledon Shipbuilding and Engineering Company, Ltd., for H. Hogarth and Sons, Ltd. There are five cargo holds and 'tween decks and a cargo handling complement of ten 5-ton derricks; the leading particulars are: length between perpendiculars, 430ft; breadth moulded, 58ft; depth moulded to shelter deck, 37ft 6in; load draught, 25ft 3in, and a gross tonnage of 5468. Steam deck machinery and steam-hydraulic steering gear is fitted and also two 100kW steam-driven generators. John G. Kincaid and Co., Ltd., built the propelling machinery, which consists of a triple-expansion reciprocating steam engine and a Bauer-Wach turbine, and develops 3350 i.h.p. and gave the ship a speed of 12½ knots on trial. Three oil-fired boilers supply superheated steam at a pressure of 220 lb per square inch

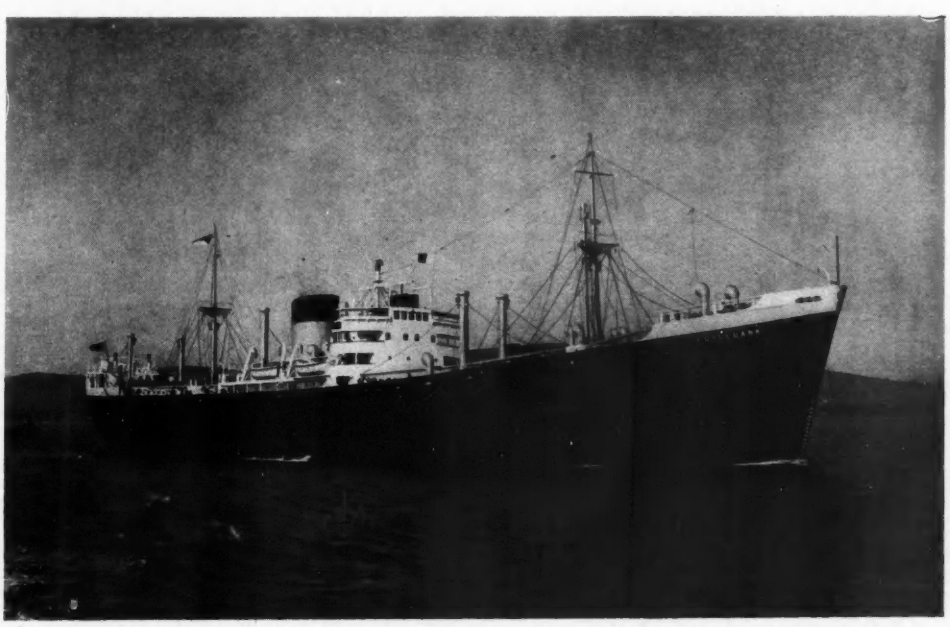
STEAM AND OIL ENGINED CARGO SHIPS



The motor cargo ship "Manes" was built by the Burntisland Shipbuilding Company, Ltd., for Motornaves Limitada, Costa Rica, and carries a deadweight of 12,480 tons on a loaded draught of 29ft and the following dimensions :—Length between perpendiculars, 435ft ; breadth, 61ft 9½in, and depth moulded, 38ft 3in. Four 3-ton, ten 5-ton and two 25-ton derricks, operated by fourteen electric winches, handle the cargo, which is carried in five holds. Electric power is provided by three 200kW diesel-driven generators and the ship is propelled by a two-stroke, single-acting Sulzer diesel engine having seven cylinders of 720mm diameter by 1250mm stroke, and developing 4825 b.h.p. at 125 r.p.m.

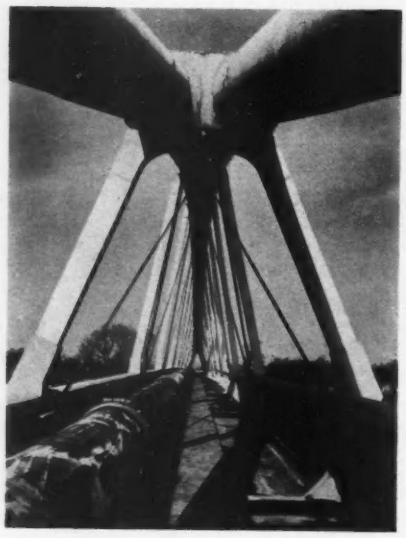


Alexander Stephen and Sons, Ltd., delivered the S.S. "Castilian" to the Westcott and Laurance Line, Ltd., for service in the Mediterranean. The ship has four cargo holds having MacGregor steel covers and served by two 5-ton, eight 7-ton and two 10-ton derricks in association with steam winches. A deadweight of 5440 tons is carried and the ship has a length between perpendiculars of 350ft 6in, a breadth moulded of 53ft, a depth moulded to shelter deck of 32ft 9in, and a gross tonnage of 3802. The electrical generators are steam driven and the propelling machinery consists of a direct-acting, inverted, triple-expansion engine and a Bauer-Wach exhaust turbine taking steam at 225 lb per square inch from three Scotch boilers



The M.V. "Foylebank" and sister ships "Cedarbank" and "Laganbank," were completed at the Belfast yard of Harland and Wolff, Ltd., for the Andrew Weir Shipping and Trading Company, Ltd., and the main dimensions are : length between perpendiculars, 425ft ; breadth moulded, 59ft ; depth moulded to shelter deck, 38ft 3in, and gross tonnage 5671. There are four main cargo holds and two deep tanks, and cargo handling equipment consists of one 25-ton, fourteen 5-ton, two 3-ton derricks and fourteen electric winches. Three 175kW diesel-driven generators provide the necessary electrical power, while two vertical boilers supply steam for ship services, and the ship is propelled by a Harland and Wolff two-stroke, single-acting, opposed-piston diesel engine having six cylinders of 620mm diameter with a combined stroke of 1870mm, and developing the requisite service power at 118 r.p.m.

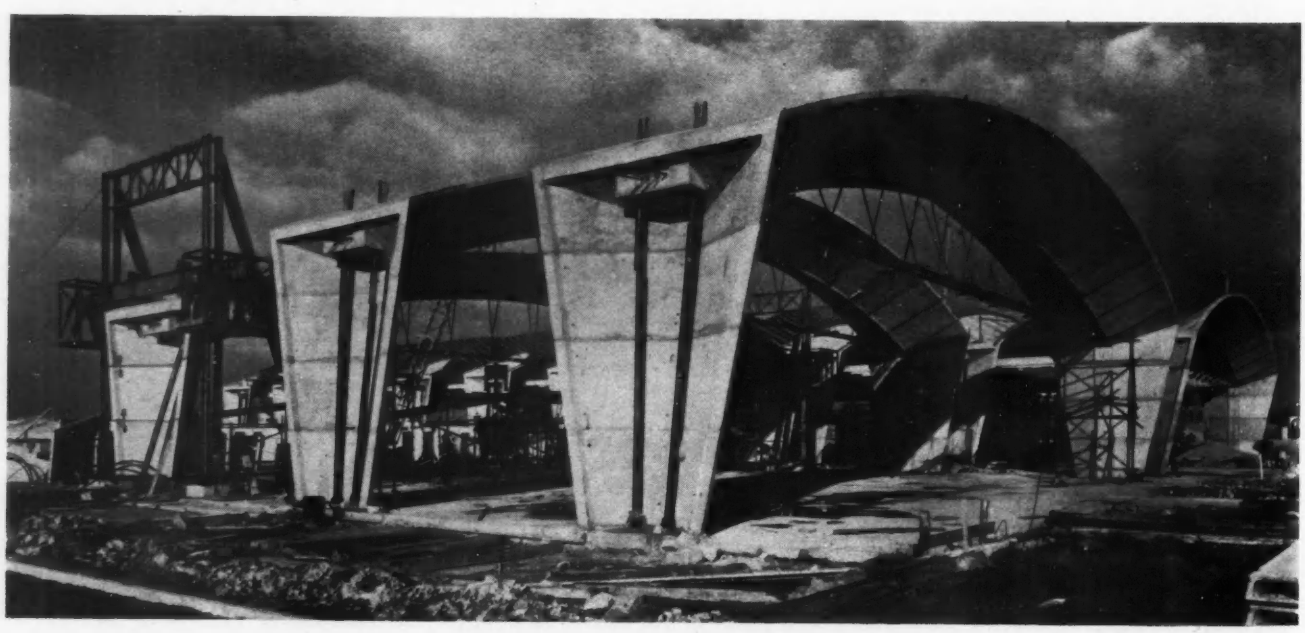
STRUCTURES IN STEEL AND PRESTRESSED CONCRETE IN 1955



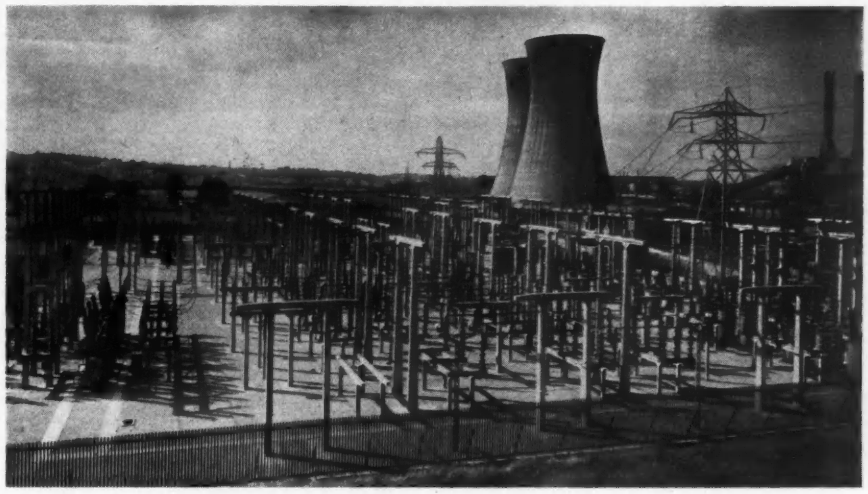
The prestressed concrete bridge over the River Trent at Gunthorpe, shown in the two illustrations above, carries only light loading, namely two lines of pipes, but is nevertheless remarkable for the slenderness of its construction. The bridge spans 250ft, has a width of 10ft, and was built on the bank and launched into position. The hangers of this bowstring girder design coincide with the pipe joints. The parapets are formed by two stiffening girders and the deck is of precast elements stressed together. It was built for Nottingham Water Department; designer, Prestressed Concrete Company, Ltd.; contractor, Crowley Russell and Co., Ltd.

The storage buildings (right) consist structurally of three-pinned portal frames, fabricated from components made by cold rolling steel strip of 10 to 14 gauge thickness. Stiffeners can be added where the frame is more highly stressed to give a better utilisation of material. Designer and manufacturer: Metal Sections, Ltd.

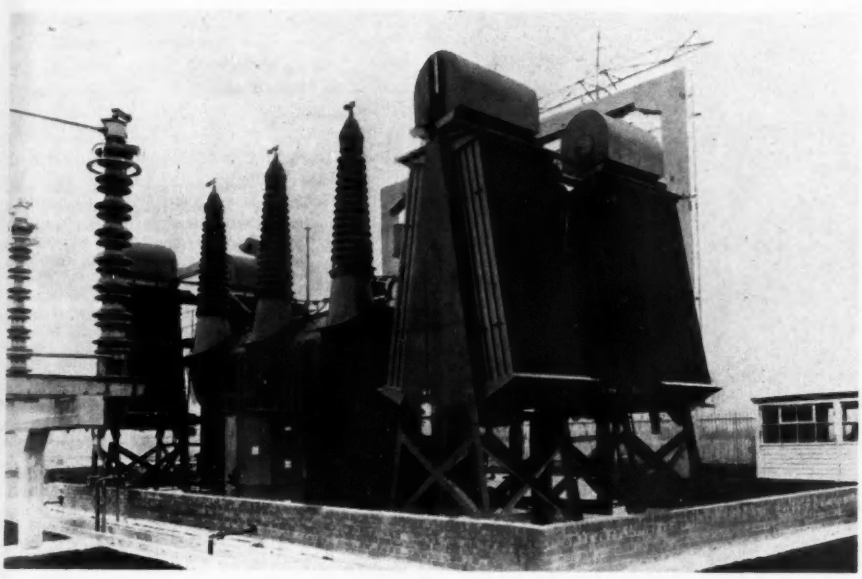
An original factory structure in precast concrete is shown below. Each arch spans 92ft and is 15ft wide; the spaces of 10ft between arches are glazed. Each arch was assembled at ground level from fourteen identical elements, the tie tensioned and then the arch raised in stages by jacking on an erection rig and progressively adding column elements. Finally the columns were prestressed. Designer and builder: Matthews and Mumby, Ltd.



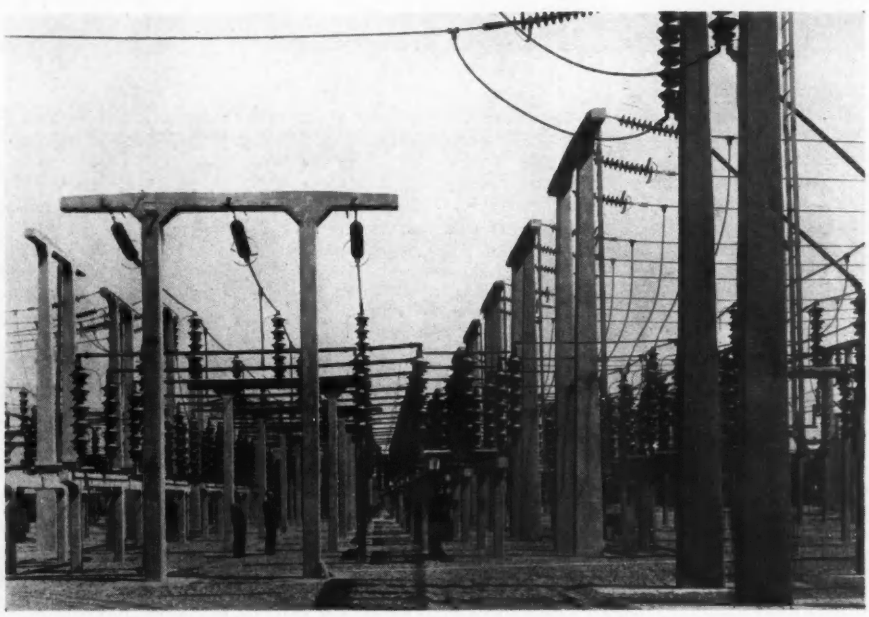
SUBSTATIONS OF THE CENTRAL ELECTRICITY AUTHORITY



To illustrate recent progress in the reinforcing of the British Grid system we show here three typical examples of outdoor substations. The first adjoins Clyde's Mill power station, where the output from two new 30MW sets is stepped up to 132kV and taken to the substation at which twin overhead lines converge from Carlisle, Motherwell, Dalmarnock and Newarthill. The Carlisle line is insulated for 275kV in anticipation of future connection to the British Supergrid. At Clyde's Mill the outdoor switchgear consists of sixteen Metropolitan-Vickers 3500MVA oil circuit breakers with isolators, &c. The circuit breakers have a "Metrosil" non-linear resistor across each of the eight breaks per phase to equalise the loading



Among the sections of the 275kV system installed during the year was that consisting of 140 miles of double-circuit line between Stella, near Newcastle upon Tyne, Carlisle and Clyde's Mill, and the line was brought into operation at 132kV pending the commissioning of the 275kV substations in 1957. The accompanying illustration of part of Stella West substation shows the first of five Parsons 120MVA, 275/132kV, three-phase auto-transformers. The second of these auto-transformers is now being erected on site

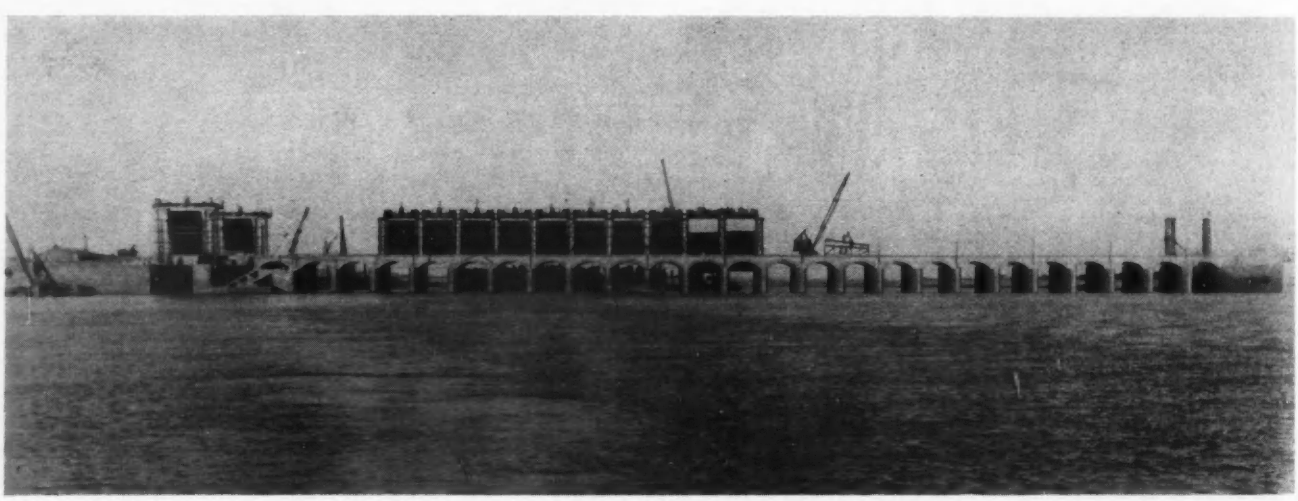


Our third illustration shows part of an isolator bay in one of the 132kV sections of the outdoor substation at Castle Donington, which occupies a 20-acre site and is one of the largest in Great Britain. The first 132kV section was commissioned in May and a second section in October, 1955. It is expected that the whole of the 132kV part of the substation will be completed in 1959. In the meantime, part of the 275kV equipment is due to be commissioned this year. The main contractor for the switchgear is the British Thomson-Houston Company, Ltd., and the foundations and structural engineering work are a Taylor Woodrow responsibility

TWO OVERSEAS CIVIL ENGINEERING WORKS

The Apapa wharf extension at Lagos, Nigeria, involves the construction of 2565ft of wharf wall, a 370ft lighter berth, and dredging and reclamation. The very extensive installations of sheds and buildings, with road and rail access, are shown here with the wharf wall in the background. Consultants, Messrs. Coode and Partners; contractor, Richard Costain, Ltd.

The Ramadi barrage is the final work of the Habbaniyah flood-relief and irrigation scheme in Iraq. Water is diverted from the River Euphrates, through an inlet channel and regulator, with an escape channel and regulator at the downstream end of the lake. Ramadi barrage is built across the river itself, and ensures that sufficient head is available to divert water into the inlet channel at times of low flow. Its total length is 209m. There are twenty-four 6m sluices, with twenty-three 2m piers, a fish ladder, and a lock 46m long by 6m wide, with turnover gates. A road bridge crosses the barrage, with a 7ft width of roadway and footpaths. Consulting engineers, Messrs. Coode and Partners; contractors, Societe Anonyme Hersent; sluice gates, Ransomes and Rapier, Ltd.



Civil Engineering in 1955

No. II—(*Concluded from page 25, January 6th*)

SCHEMES for flood protection in progress last year included those on the Trent, the Lee and the Great Ouse. The Trent River Board's Nottingham flood protection scheme is not due for completion until later this year, but last May a section of the scheme—the Holme sluices—was inaugurated. The channel here is controlled by five roller sluice gates, each 40ft wide by 16ft 6in deep, which normally operate automatically.

Work has been proceeding for some time on a scheme to alleviate flooding in parts of Edmonton, Tottenham, Walthamstow, Leyton, Hackney and West Ham. Powers to carry out the works were given by the Lee Conservancy Catchment Board Act, 1938, and the scheme has been estimated to cost £2,400,000. It makes provision for enlarging about 1½ miles of the River Lee and the construction of a new flood relief channel some 3¾ miles in length, together with the improvement of some miles of other watercourses. Nine new bridges to carry roads or railways will be built as well as a number of footbridges and in some cases flood channels will be constructed in culvert.

Most of the work of excavation necessary for the improvement of the River Lee and a new reinforced concrete footbridge with three spans totalling 148ft had been carried out before the beginning of the year. Work was proceeding in 1955, however, on the construction of a new reinforced concrete bridge having two 55ft spans to carry Carpenters Road over the improved channel, and this necessitated the erection of a temporary road bridge pending the completion of the permanent works.

Work on the construction of about 2000ft of the new flood relief channel was completed about eighteen months ago at its downstream end. The new channel is approximately 55ft in width and has mass concrete retaining walls with a concrete invert; over a length about 1000ft it is in culvert, being decked with prestressed concrete beams.

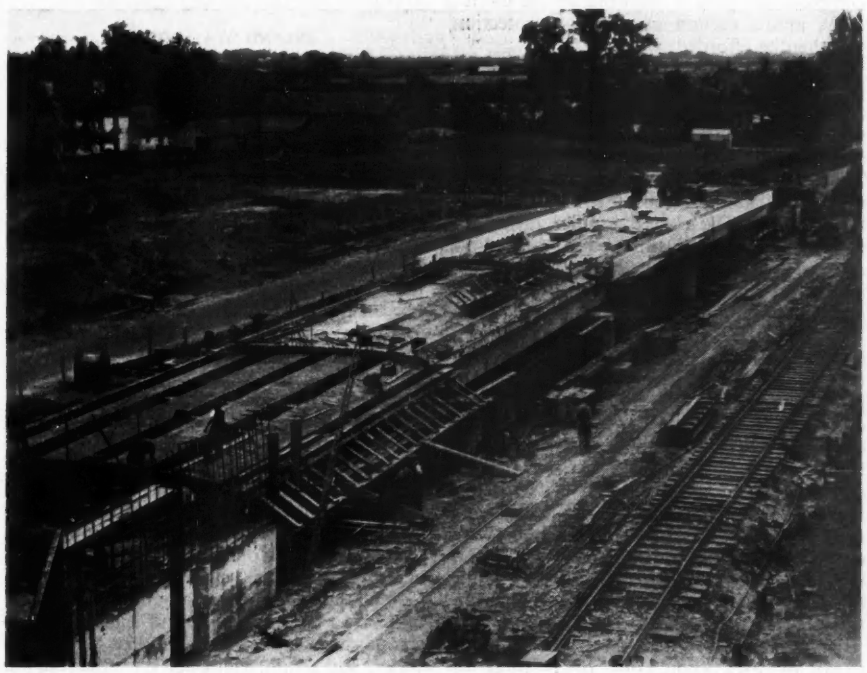
The construction of a new prestressed concrete bridge of about 60ft span to carry Lea Bridge Road over the new flood relief channel was commenced recently and a length of about 2100ft of the new channel, together with a prestressed concrete footbridge upstream of Lea Bridge Road, was completed, the final works of reinstatement of adjacent lands being in hand at the end of the year.

At Low Hall the new flood relief channel will cross under five railway tracks and a new bridge is now under construction. The bridge has three spans of 25ft, the deck being of precast prestressed concrete units. A further section of concrete-lined open channel upstream of Low Hall was completed in 1955. A number of houses were demolished to make way for the new flood channel and a new estate of thirty-five houses was built by the Catchment Board to rehouse the displaced occupants. The construction of the new channel at Elmfield Road, the site where most of the houses were demolished, is in hand.

At Copper Mill Lane work commenced on the construction of a new bridge, consisting of post-tensioned concrete beams converted into "T" beams by an *in situ* reinforced concrete slab, and work is just beginning on a length of about 2500ft of open flood channel upstream of Copper Mill Lane. It is expected that in the near future work will commence on another section of the new flood relief channel and also on the widening, inverting and walling of a length of some 3500ft of the Pymmes Brook. All of this work is under the direction of Mr. N. Medrington, chief engineer of the Lee Conservancy Catchment Board. The main contractors for the works carried out on the scheme are George Wimpey and Co., Ltd., Concrete Piling, Ltd., Ormac Construction Co., Ltd., W. and C. French, Ltd., and Holland & Hannen and Cubitts, Ltd.

Great Ouse Flood Protection Scheme

Nineteen fifty-five was the first full year of work on the Great Ouse flood protection scheme, which is intended to protect the Fens from flooding by fresh water after excessive rain and snow, to prevent the North Sea floods, such as that of January, 1953, breaching the river banks and doing serious damage to the Fens, and lastly to improve the drainage of the whole basin of the River Great Ouse, which is over 2,000,000 acres in extent.



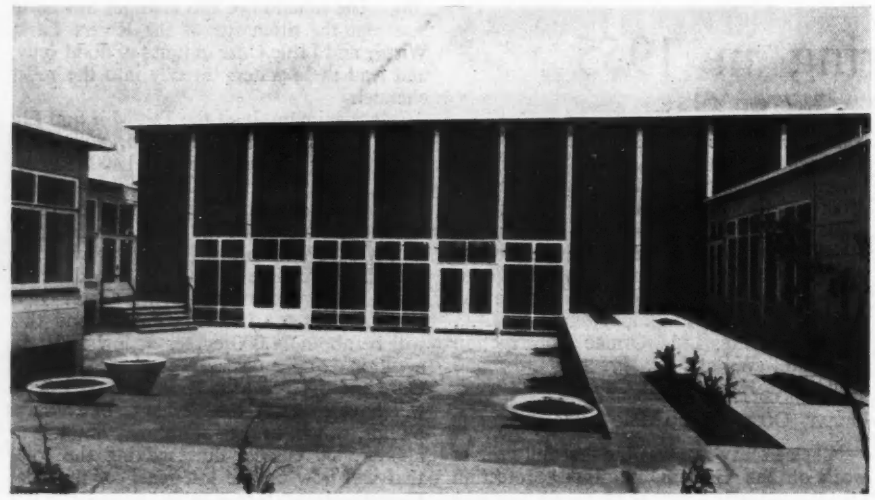
Progress made last September on the Saddlebow bridge, one of several bridges which will cross the flood relief channel of the Great Ouse scheme, is shown here. The cofferdam enclosing the bridge piers may be noted

The discharge capacity of the lower reach of the Ouse from Denver to the sea will be practically doubled by building a relief channel parallel to it with a length of about 10½ miles, the general dimensions of which are bed widths varying from 175ft to 200ft, with a depth of excavation of about 20ft. The second part of the scheme will allow for the remodelling of the Ten Mile and Ely Ouse Rivers for a length of about 21 miles. The remodelling will consist of strengthening and heightening the banks and dredging the bed so that the river will take its proper share of the discharges that may be expected in a maximum flood. The third part will comprise the cut-off channel, with a length of about 28 miles. Its bed width will be 70ft and the depth of cutting will be between 15ft and 20ft. The function of this channel will be to intercept the discharge of the Rivers Lark, Wissey and Little Ouse in times of flood only, and lead these waters directly into the relief channel.

In a maximum flood the Ten Mile and Ely Ouse Rivers, when remodelled, will carry 6100 cusecs; the cut-off channel 4000 cusecs, and the relief channel 10,100 cusecs at low tide. The whole of the discharge of these rivers will flow down the relief channel, and thus will leave the present tidal river available for the discharge of the Bedford Ouse draining the western part of the Great Ouse catchment area. In a maximum flood this will be about 11,000 cusecs at low tide. In addition to the discharges of the Bedford Ouse and the Ten Mile River, the tidal Ouse will have to carry the discharge of drainage pumps, which, in the future, may amount to about 3000 cusecs, thus making the total that will flow on the last reach of the tidal Ouse some 24,000 cusecs.

The tide flows unobstructed up the Tidal Ouse and Bedford Ouse. It is shut off from the Ten Mile River by the Denver sluice, which has automatic gates that are closed as the tide rises; similarly, automatic gates will be fitted on the tail sluice of the relief channel, so that the tide cannot enter that river either. The effect of these sluices will be that the whole of the excavated capacity of the relief channel, Ten Mile and Ely Ouse, and the cut-off channel, will be available for storing fresh water floods during the period of high tide, and the system is so designed that the reservoirs will be completely emptied by the end of the ebb. The maximum flood that has been recorded was that of March, 1947, which occurred at a neap tide. The scheme, however, has been designed for a similar fresh water flood occurring at a spring tide.

The first part of the scheme, which consists of the excavation of the relief channel, five road bridges, a railway bridge, a head sluice and a tail sluice, was let to Sir Robert McAlpine (Leicester), Ltd., at a sum of nearly £3,000,000, and work was started during



Worthing Technical High School is the prototype building of a prefabricated structural system using precast and prestressed concrete elements

1954. The plant on the site is sufficient to complete this part of the work by the end of 1959, and a certain measure of protection will then be afforded.

The Great Ouse River Board has decided to begin the second part of the work, namely the remodelling of the Ten Mile and Ely Ouse Rivers during 1956, to be finished about the same time as the relief channel. These two parts will afford protection against nearly all floods except the maximum, or those near it. The exact date for carrying out the execution of the third part—the cut-off channel—which would complete the scheme, is not yet fixed, but it is hoped to make a start in 1957.

To meet the extreme conditions, as experienced in 1947, but occurring at a high spring tide, additional storage is made available by a reservoir near Denver, which consists merely of two banks enclosing an agricultural area of over 500 acres. This area will normally be cultivated as at present, but will carry a servitude which will enable the River Board to cut the banks and flood the fields when necessary. There will be a very large amount of surplus spoil from the relief channel, which is to be used to heighten the banks of the tidal river to give security from the recurrence of a North Sea flood.

By the end of 1955 about 1,500,000 cubic yards of excavation, out of a total of 12,000,000, had been carried out on the relief channel. Conveyors were employed to carry spoil from the excavation to the berms formed beside the channel. Earthwork for straightening the Magdalen bend, a meander in the river which crosses the path of the relief channel, was also completed, ready for the diversion of the river from the bend during next summer. The abutments and wing walls of the tail sluice consist of monoliths, and monolith sinking was completed during the year.

Of the various bridges on the relief channel, Saddlebow bridge was completed and opened to traffic, and Wigginhall bridge was well advanced. Magdalen road bridge and a small bridge on the Polver drain were also under way. The illustration on page 49 shows progress made at Saddlebow bridge, last July. The bridge is of reinforced concrete, with five spans, the side spans of 48ft and the three central ones of 60ft. A cofferdam, which can be seen in the illustration, was built round the bridge site and excavated down to formation level. The rest of the channel near the bridge remains to be excavated. The consulting engineers for the Great Ouse flood protection scheme are Sir Murdoch MacDonald and Partners.

Inland Waterways

Last April, a board of survey appointed by the British Transport Commission, published its report on the canal system. The report pointed out that 336 miles of canals carried substantial traffic and offered scope for commercial development. Waterways with insufficient commercial prospects to justify keeping them for navigation totalled 771 miles ; they were being maintained by the Commission, the report stated, for reasons wholly unconnected with transport. On the borderline between these two extremes were 994 miles of waterways worth retaining for transport under existing conditions. In a leading article in The Engineer of April 22nd last, we commented on the board of survey's report and pointed out that, over a period of rapid development in technical thought, little attention had been paid to canals, and it was not possible to say what a modern canal system—possibly involving multi-purpose uses, such as water conservation and flood control—would be able to achieve. However, the British Transport Commission's canals, nearly all of which were built over a hundred years ago, are not standardised in the size of locks, depths of water, and so on, and offer only the limited possibilities explained in the report.

The British Transport Commission made a start during the year with its policy of development for the 336 miles of specially-favoured canals, and announced various development schemes, costing altogether £500,000, as a first instalment of major schemes which are envisaged.

Roads

The year under review saw the announcement, last February, of the Government's programme of road construction, and a list of schemes to be authorised in 1955–56 was published. This matter also was commented upon quite fully in The Engineer at the time (our issue of February 11th and, later, after a debate in the House, in a leader on July 15th), and we drew attention to the fact that the actual rate of expenditure was uncertain ; a comparison between the road and rail plans, which, as it happened, were published at almost the same time, appeared to be all to the disadvantage of the roads. The Government's plans included one motor road—the London/Yorkshire motorway—and the route of the first stage of this scheme, the London to Birmingham section, was published later in the year. It is expected that this first section will be completed in about 3½ years time.

Since the announcement in February, statements of schemes authorised have been given in the House, and on December 14th a list of schemes on which work had been started was given by the Minister. Those trunk road schemes already under way are listed in the 1955 edition of our *Tabular Summary of Civil Engineering Contracts*. The only major one (over £1,000,000) is the Middlesex County Council's scheme for the extension of Cromwell Road, which is due for completion in 1959, except for a flyover crossing at Chiswick High Road. Another section of the Cromwell Road scheme is being built by the London County Council and is due for completion this spring. One other urban route—the Digbeth highway in Birmingham—was opened last July. This road widening scheme, comprising dual carriageways about a thousand yards in length, cost about £250,000 to build, and is believed to be the only scheme of its kind to be completed in a heavily built-up area since the war.

These two road schemes draw attention to the serious problem of providing adequate highway and parking systems to serve the central areas of cities and large towns, a problem which is of basic importance to the future of road transport. It has been largely neglected in the Government's road plan, and the two works cited above are probably the only examples of actual construction of their kind, apart from purely local and minor improvements. Nevertheless, there were interesting developments during 1955 relating to this particular problem and to the social and technical problems of motorways generally. We refer particularly to the publication of a plan, prepared some time ago by the London County Council's engineering staff, for a motorway ring serving Central London, in the paper " The Planning of Ring Roads with Special Reference to London," by Mr. F. A. Rayfield, presented at the Institution of Civil Engineers on December 6th, and discussed in The Engineer of December 23rd last. The proposal envisages a ring road built to motorway standards in cutting and tunnel, and on viaducts, over various different lengths, with nine access points ; it would cut through the eastern edge of Hyde Park (in tunnel) and then turn in an east-west direction, crossing the Thames just below Tower Bridge (in tunnel) and again at Vauxhall. The entire scheme would cost £130 million to build and was considered to be economically justifiable. The author pointed out that if a 50 per cent increase in traffic had to be accommodated in Central London, the ring road project would accomplish that at less than half the cost of a comparable set of normal surface widenings and intersection improvements.

We would also like to refer to the series of articles, " America's Approach to the Road Problem " (The Engineer, September 2nd to 16th last), by Messrs. W. H. Glanville and R. H. Moore, in which the significance of American road experience as it affected Great Britain was reviewed. The vast American road plan was described, and its justification, according to American authorities, was explained and commented upon ; road safety was also discussed.

The years' most original, and indeed its most controversial, contribution was, however, undoubtedly the paper by Brigadier T. I. Lloyd, " The Potentialities of the British Railways' System as a Reserved Roadway System " (Institution of Civil Engineers, April 26th). The Brigadier's

proposal—for an "amalgam" of road and rail transport, the permanent way of the railway being converted into a road surface, on which large vehicles would be operated to professional standards—aroused rather more violent rejection or support than is customary with technical papers. The proceedings of the meeting of April 26th have since been published*; they include two contributions, each of which outlines a possible application of this suggestion on a limited scale, thus providing a sort of "pilot" scheme, which would give experience of the general principles involved. An appeal has also been made in Parliament for the conversion of the line from Inverness to Wick. Brigadier Lloyd did not consider that he had proved the case for a modernised highway system, and referred to a description of the motorways in the Government's road plan as "pipes with their ends blocked." The essence of railway conversion, he contended, was that it would provide high-speed routes where they were most needed, which was through urban and metropolitan areas.

It is evident that technical thought is by no means agreed on the best methods of circulating and parking road traffic in cities and large towns, whereas the construction of main routes in open country is comparatively straightforward. It will, therefore, be particularly interesting to hear the views which will be put forward at the international conference on urban motorways which the British Road Federation has organised for next September.

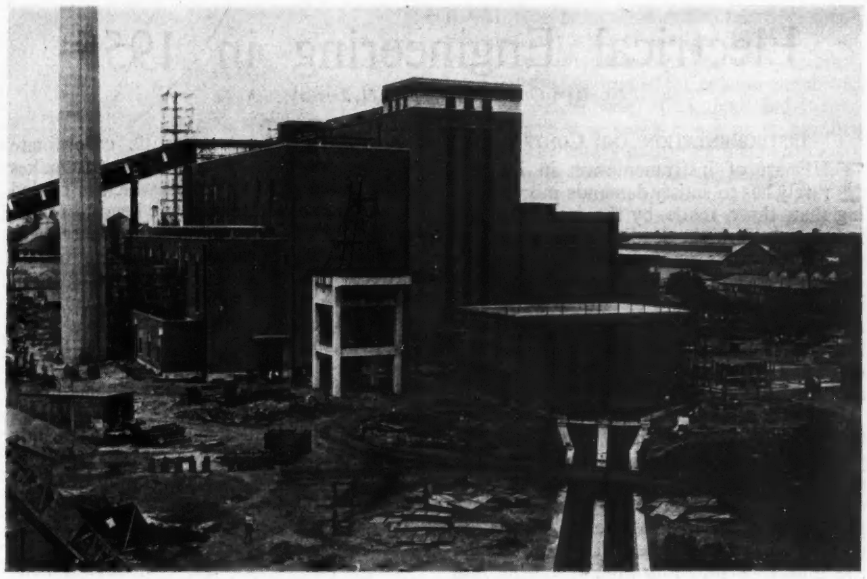
Some Structural Works

Three structures erected during the year, which are noteworthy for their novelty of material or design, are illustrated on Plate 6. The year again saw considerable activity in the structural use of concrete, and we described several examples of such work, including a large factory at Nuneaton (The Engineer, September 23rd last), built by Beechams Buildings, Ltd. This structure covers 200,000 square feet; it was erected from precast elements made at the firm's factory at Shipston-upon-Stour, and transported to the site for erection. The largest precast unit weighed about 6 tons and units up to 40ft in length were used.

Prefabrication has had a particular vogue in the construction of school buildings over the past few years, and various materials—steel, aluminium and timber—have been used as a basis for prefabricated designs. Here we illustrate a school completed last year at Worthing, which was built from precast concrete elements, making liberal use of prestressing in a system of construction known as the "Intergrid" system. The structural designers were the Prestressed Concrete Company, Ltd., and the main contractor Gilbert Ash, Ltd.

The illustration shows a single-storey building. The precast, pretensioned columns are clearly shown; they are "clad" with precast concrete slabs, each extending the full width between columns, and cast with a decorative external surface. The roofs and ceilings of the "intergrid" system are built from braced precast concrete elements, each 3ft 4in long, which form a grid over the area to be covered, and are post-tensioned when in position. Concrete slabs then complete the roof. The whole building requires only a few basic precast elements. Considerable attention has been paid to detailing to cover all the requirements simply, and to simple yet adequate methods of erection and weather-proofing. For instance, four kinds of column and four precast column heads cover all possible combinations of beam and column layout in the building.

* *Proc. I.C.E.*, Part I, Vol. 4, No. 6, November 1955.



Ijora "B" power station at Lagos, Nigeria, was completed at the end of 1955. It has a buoyant raft foundation

Two developments of the year concerned with construction in steel have already been referred to—the use, on a large scale, of cold-formed steel for structural work (Plate 6) and the full-scale tests on composite steel and concrete stanchions. One interesting design problem was that described in The Engineer of September 30th last, for a cylindrical raw sugar silo, 160ft in diameter, built principally from steel strakes assembled both by riveting and welding.

Ijora "B" Power Station

In December, 1955, the Ijora "B" power station at Lagos, which is owned by the Electricity Corporation of Nigeria, was completed. The power station is shown in the accompanying illustration; it houses two 12·5MW turbo-alternator sets, operating at 3000 r.p.m., 50 c/s, 11kV and 0·8 p.f., four 75 klb/hr boilers, and the associated equipment required for the operation of this principal plant.

From the civil engineering point of view the interest of the station lies in its foundation construction. The site is reclaimed land, with 3ft to 8ft of sand overlaying 25ft to 40ft of compressible organic silt. Below the silt there is sand and sandy clay, and no satisfactory load could be carried on a test pile driven to a depth of 120ft. A buoyant raft was therefore constructed to carry the power station loads.

The raft is 45,000 square feet in area and is of reinforced concrete. Its depth varies from 14ft to 16½ft, and it is divided by cross walls into cells varying from 14ft by 8ft 3in to 7ft by 6ft 2in, in size. The internal walls are 15in thick, the external walls and bottom are 18in thick, and the roof is 13in thick. The total weight of the raft is 40,000 tons, and of the buildings it carries 28,000 tons. About 40,000 tons of spoil was dug away for its construction. It is "tanked" with Ruberoid and bitumen, as the subsoil water is acidic. Flexibility is provided in the raft to allow for settlement where the circulating water conduits enter or leave it. There are two 275ft long circulating water channels, with a pump house which is a separate structure. The main building is of structural steel and concrete hollow blocks, and particular attention has been paid to heat insulation, with bright reflecting surfaces, so that conditions inside it will be tolerably comfortable. The consulting engineers for Ijora "B" power station were Messrs. Coode and Partners for the civil engineering, and Messrs. Preece, Cardew and Rider for the electrical work. The main civil engineering contractor was Richard Costain, Ltd.

Books of Reference

Mechanical World Year Book, 1956. Manchester: Emmott and Co., Ltd., 31, King Street West. Price 4s. 6d.—The new edition of this useful handbook follows the same general lines as in previous years, and the necessary revisions and additions have been made to bring the information it gives up-to-date. This year the section on the continuous flow gas turbine has been replaced by a new section dealing generally with the design of gas turbine plants.

The Gas Journal Calendar and Directory, 1956. London: Walter King, Ltd., 11, Bolt Court, Fleet Street, E.C.4. Price 25s.—The three main sections of this year book comprise a directory of the gas industry, a handbook of technical data, and trade directories and display. The information it contains has been revised and a new section on instrumentation has been introduced in the handbook section, which consists of a memorandum of gasworks practice with general information and tables for reference purposes.

Radio Tube Vade Mecum. Edited by Dr. J. A. Gijsen. Twelfth edition. Antwerp: P. H. Brans, Ltd.; obtainable from Bailey Bros. and Swinfen, Ltd., 46, St. Giles High Street, London, W.C.2. Price 27s. 6d.—The present edition of this handbook lists radio tubes from all parts of the world according to type number or letter, giving in each case the principal operational data, application and socket connections. Equivalencies have not been indicated systematically, since to do so would have exceeded the scope of the book, but in some cases of special importance equivalents are given. Some obsolete types have been deleted from the tables, whilst Army valves are dealt with in the same publisher's *Equivalent Valves Vade Mecum*, where may also be found more extensive comparison data.

Books Received

Flood Estimation and Control. Third edition. By B. D. Richards. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 35s.

Color Television Engineering. By John W. Wentworth. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 60s.

Winding Engine Calculations for the Mining Engineer. Second revised edition. By A. B. Price. Kent: The General Electric Company, Ltd., Fraser and Chalmers Engineering Works, Erith. Price 30s.

Electrical Engineering in 1955

No. II—(*Concluded from page* 21, *January 6th*)

Instrumentation and Control

THE art of instrumentation in industry rarely has to satisfy demands more exacting than those made by the iron and steel industry. Here the leading requirement of reliability with a minimum of maintenance is even more important than accuracy, and it is interesting to find electronic techniques for measurement and control becoming firmly established in an industry where the operating conditions are generally very arduous.

Some current trends in rolling mill practice for example, were given in a recent I.E.E. paper* which described the comprehensive system of instrumentation on a new 14in experimental rolling mill in the British Iron and Steel Research Association (B.I.S.R.A.) laboratories at Sheffield. Briefly, the mill is a 14in four-high reversible mill equipped with coilers by which front and back tension can be applied. The force applied to the rolls and, therefore, the gauge reduction per pass is controlled by motor-driven screws which apply the downward force on the roll bearings. In this installation the main parameters in the rolling process—roll force on each side of the mill, front and back strip tensions and strip gauge on leaving the mill—are continuously indicated, by the B.I.S.R.A. gaugemeter principle, on high-speed servo-operated potentiometric indicators fitted with large pointers and dials. The instrumentation scheme is arranged to serve as a model for industrial mills of this class and there are facilities for experiments with various systems of automatic gauge control. A simple system of on/off control of the a.c. screw motors according to the gauge deviation has been successfully operated with a tolerance of only +0·0005in. Facilities are also provided for switching to automatic tension control, based on measured tensions as an alternative to the present method of control of coiler motor current with correction for radius of build-up.

A resistance-strain-gauge bridge forms the basis of all three measurements—roll force, strip tension and gauge. In each case the basic circuit embodies an established automatic potentiometric system of indication in which the output signal from the bridge is compared with a signal generated by a linear potentiometer and any difference signal is amplified and used to drive a servo-motor coupled to this resetting potentiometer. The system therefore operates until a balance is achieved in which the angular position of the resetting potentiometer is a continuous measure of the amount of unbalance of the strain-gauge bridge.

The authors of the paper state that the systems of measurement and display of roll loads, strip tension and strip gauge described, have proved satisfactory in service and will be a useful model upon which industrial instrumentation schemes might be based. They conclude that the experiments carried out with a simple system of automatic gauge control by on/off control of the screw motors, using the gauge error indicator to initiate the control action, have shown that this system has considerable promise for use on some industrial mills.

Developments in the automatic control of machine tools have been following two main lines—profiling and automatic co-ordinate control. Profiling or tracer control makes use of a template or model which is copied by causing an electromagnetic head to follow the model and by making the consequent movement of the head control the relationship between the work and the cutting tool. More than a year ago a three-dimensional contour+control equipment was made and supplied to Briggs, Ltd., by the British Thomson-Houston Company, Ltd. This company has also developed single-dimensional contouring equipment for the machining of turbine blades in the B.T.H. turbine factory which is being built at Larne in Northern Ireland. Control equipment for the copy turning of non-re-entrant forms has also been made and supplied to Craven Brothers, Ltd.

The other main line of development mentioned above, automatic co-ordinate control, involves the automatic power positioning of the work relatively to a cutting tool on the basis of data set-up manually or recorded data such as punched cards or magnetic tape. During the year under review such an automatic control system was made by the British Thomson-Houston Company, Ltd., for Kearns, Ltd., and is now in operation on this company's type " O " horizontal borer (Fig. 4). With this method of control, power positioning of the machine table can be achieved with an accuracy of about 0·0002in from information manually set-up on dials or from punched card.

Part of a typical control system for an atomic power plant is illustrated in Fig. 5, which shows an actuating mechanism for the combined control and shut-off rods of a thermal reactor. The mechanism, which is made by Metropolitan-Vickers Electrical Company, Ltd., is one of 120 being supplied for the Calder Hall " A " power station of the U.K. Atomic Energy Authority. It is designed to provide a slow " out " speed and two faster " in " speeds, and to hold the rod in any required position. It is also intended to give a controlled shut-off of the reactor independently of the electrical supply. The mechanism consists of a synchronous control torque motor, fed from a variable-frequency supply, driving a cable reel through a 20 : 1 reduction gear. The speed of the rods to the shut-off condition is controlled by a permanent magnet eddy-current brake. Rod position indication is given by a geared magslip transmitter. The whole mechanism is dry lubricated by molybdenum disulphide.

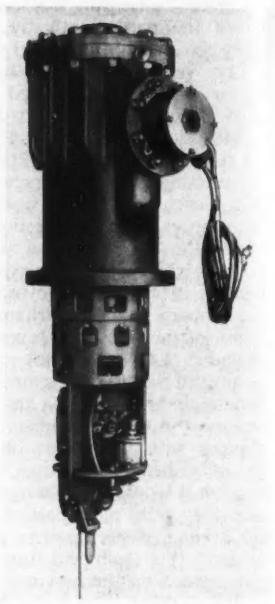


Fig. 5—Actuating mechanism for combined control and shut-off rods of a thermal reactor. It is one of 120 Metropolitan-Vickers equipments for Calder Hall " A " power station. It provides a slow " out " speed and two faster " in " speeds, and can hold the rod in any required position

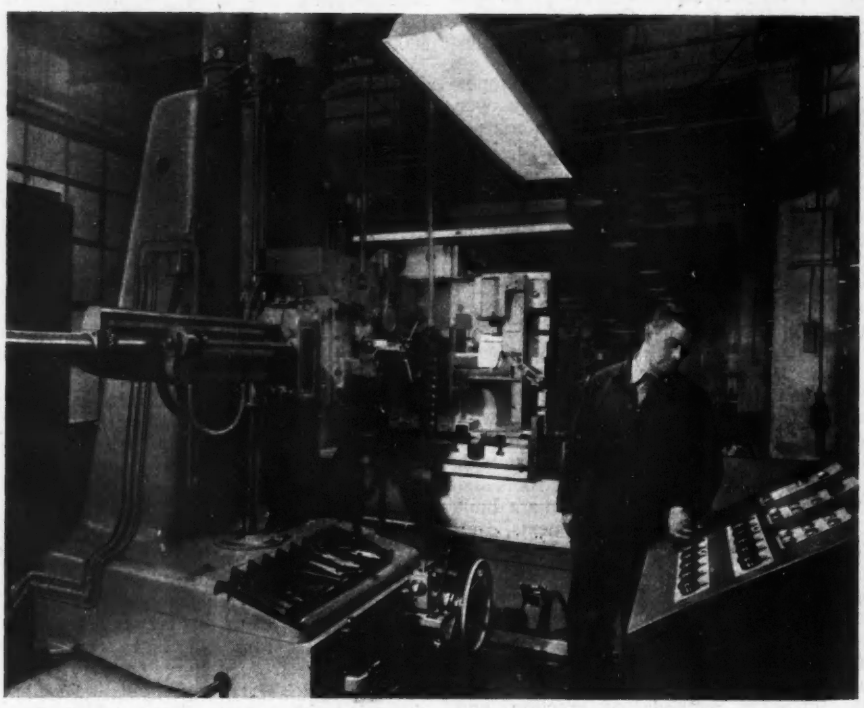


Fig. 4—Electronic control system applied by B.T.H. to a Kearns horizontal boring machine. Power positioning of the machine table is effected with an accuracy of 0·0002in from information set manually on dials

* " Instrumentation of a 14in Experimental Rolling Mill " by S.S. Carlisle and G.W. Alderton. Abstracted in THE ENGINEER December 9, 1955, pages 846-849.

Accelerometers and strain gauges making use of the piezo-electric properties of barium titanate have been developed by the General Electric Company, Ltd. These instruments exploit the advantages of barium titanate compared with quartz—cheapness and better electromechanical coupling combined with a lower output impedance. The accelerometers are simple assemblies consisting of a barium titanate element soldered between two brass pieces. They can be used to measure transient accelerations up to 1000*g* at frequencies between 20 c/s and 20 kc/s.

The strain gauges, or vibration pick-ups, consist of thin rectangular plates of barium titanate and can be used either for detecting or exciting vibrations. When used for excitation (in turbine research, for example) the excitation frequency can be varied within wide limits and mechanical resonances can be shown on an indicating gauge.

Another measuring device which has proved to have a variety of applications is the G.E.C.-S.E.I. electromechanical transducer system.† Essentially the system involves an electromagnetic measuring or detecting head and a dynamometer moving coil instrument which indicates the change detected by the measuring head. As such the transducer can be used for measuring changes in length or displacements ; by fitting a pressure-sensitive element, such as a diaphragm, to the armature of the measuring head, the system can be adapted for the measurement of pressure. A useful example of the first kind is in the measurement of the absolute longitudinal expansion of a turbine casing and of the differential axial expansion of the shaft relatively to the casing. In applications of this kind the dynamometer " receiver " instrument can be an indicator or a recorder, which can be incorporated in the turbine control panel. It is stated that displacements of less than 0·001in can be measured directly in this way with an accuracy of 1 per cent of full-scale reading.

† "Remote Indication by Electromagnetic Transducers in Atomic Factories." THE ENGINEER, April 29, 1955.

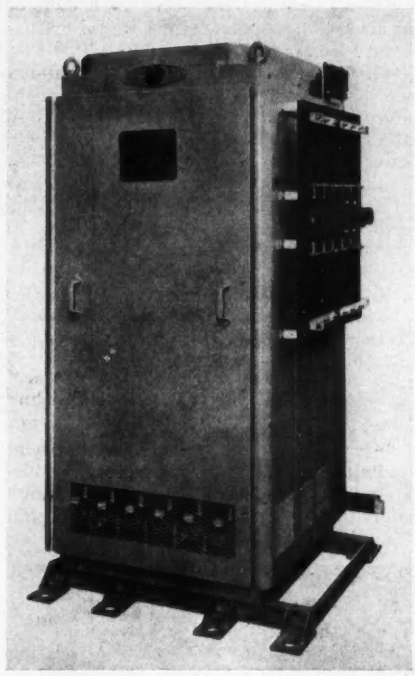


Fig. 7—Air-cooled 750kW germanium rectifier as installed on an electric locomotive for power conversion to supply the traction motors. This equipment is the latest to be tested on the Lancaster-Morecambe-Heysham line, which is being used by British Railways as a proving ground for the 50 c/s, single-phase system of railway electrification

Mechanical Contact Rectifier

Rectifying equipment was the subject of some interesting developments in 1955. For example, further progress was made with the B.T.H. mechanical contact rectifier mentioned in our issue of January 21, 1955, page 97. A prototype equipment was installed in one of the factories of the general chemicals division of Imperial Chemical Industries, Ltd. There it is being operated in parallel with a large rotary converter installation, to yield, under commercial conditions, data which can be incorporated in the design of the ten 15,000A, 270V contact rectifier equipments which the British Thomson-Houston Company, Ltd., is making for the same customer.

As a result of this experience with the prototype, the mechanical unit of the production design, complete with its ventilating and lubricating system, is housed in a sheet steel cubicle mounted immediately above the " comreactor " assembly which is installed in a basement under the operating floor. The premagnetisation and control apparatus is of reduced size and is enclosed in folded sheet steel cubicles which are aligned with the main d.c. switchgear. The first of the ten production equipments is being erected on site and is due to be commissioned early this year.

Germanium Power Rectifiers

Even more significant was the year's progress with germanium power rectifiers. The first equipment of this kind to go into normal commercial service in this country was a 1000kW, 255V, 2920A equipment which was made by the British Thomson-Houston Company, Ltd., for the general chemicals division of Imperial Chemical Industries. This germanium rectifier has replaced one of a number of rotary converters and is now operating in parallel with the remainder, on electrolytic duties which involve prolonged periods of continuous operation at full load. The new rectifier obtains its a.c. supply from the existing rotary-converter transformer, and for this service the transformer secondary con-

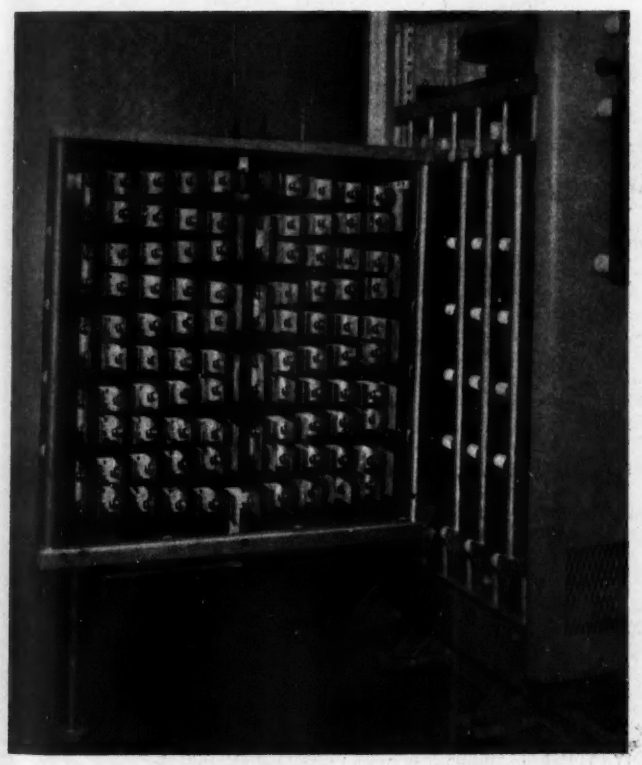


Fig. 6—Air-cooled 750kW germanium rectifier for power conversion on an electric locomotive. One of the racks carrying the germanium rectifier units is here shown withdrawn from the cubicle

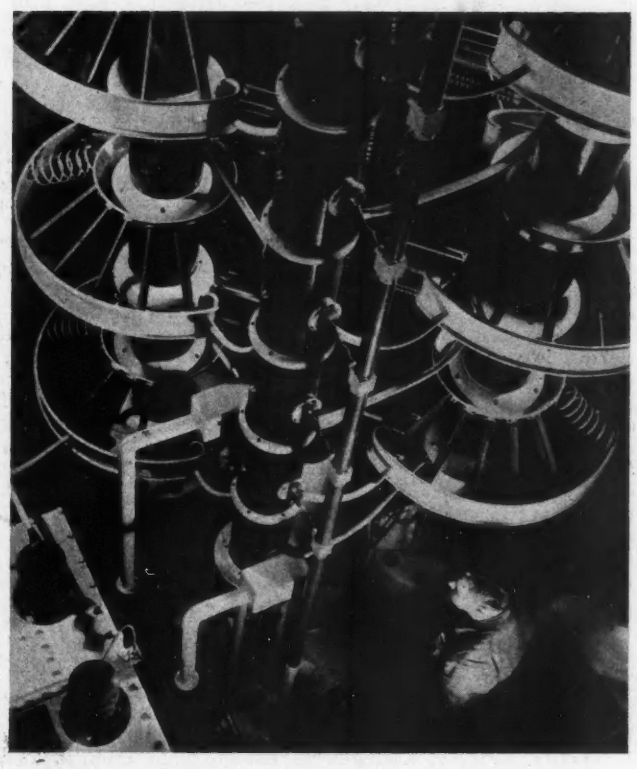


Fig. 8—Transient generator for production testing of porcelain insulators. Eight condensers are charged in parallel and discharged in series through inductance, producing oscillatory transients at a recurrent frequency of 50 c/s

nections have been changed from diametric to delta. The rectifier equipment is housed in two cubicles (as illustrated in our issue of September 30, 1955) and consists of a series-parallel arrangement of germanium rectifier cells connected to form a six-phase full-wave bridge with an output of 7·4kW per cubic foot of volume or 55·5kW per square foot of floor space occupied.

Each rectifier cubicle is separately ventilated by a propeller fan whereby air is drawn over the germanium cells through openings at the base of the cubicle and discharged at the top. Protection against fan failure is given by air flow relays which sound an alarm if the speed of the air through the cubicle should reach a predetermined low value and (after a time interval to permit the load to be transferred to the rotary converters) opens the d.c. circuit breaker.

Individual fuses are provided for the parallel circuits into which the germanium cells are grouped and when a fuse blows an arrangement of current balance relays mounted in the cubicle sounds an alarm as a warning for the operator to reduce the load on the rectifiers.

More interesting still are the possibilities foreshadowed by the recent announcement that a similar B.T.H. germanium rectifier has been installed and tested on one of the electric trains which are undergoing trials on the Lancaster–Morecambe–Heysham line, as electrified experimentally to test the merits of the 50 c/s single-phase system. It may be recalled, in passing, that this system of electrification is being widely adopted in the north-eastern region of French Railways.‡ Of the four types of locomotives which are in service in this part of the French system, one uses ignitrons to convert the 25kV, 50 c/s, single-phase power at the pantograph, into a direct current supply for the traction motors. The B.T.H. germanium rectifier, however, is believed to be the first of its kind to be used for current conversion on a locomotive. It is a 750kW air-cooled equipment arranged for full-wave rectification and is illustrated in Figs. 6 and 7.

‡ THE ENGINEER, January 6, 1956, pages 31-32.

A useful perspective of the present state of the art and of its potentialities was given in a recent I.E.E. paper "Germanium and Silicon Power Rectifiers."§ In this paper, the authors gave details of the 1000kW equipment mentioned above and stated that an 18MW installation is now being built to supply power to two 30kA electrolytic cell lines—an installation which is believed to be the largest germanium rectifier plant on order in the world. The authors of this paper also referred to the properties and potentialities of silicon as a power rectifier, bearing in mind that its junction temperature may be raised to a maximum of about 300 deg. Cent. compared with 100 deg. Cent. in the case of germanium.

Transient Generator for Testing Porcelain Insulators

A new design of high-voltage equipment for testing insulators during factory production has been developed in the research laboratory of the British Thomson-Houston Company, Ltd., Rugby, and was installed last year in the factory of Doulton and Co., Ltd., Tamworth. High-voltage insulators are usually subjected to impulse testing, but the new equipment, on the other hand, is designed to effect a sustained voltage test in which the applied voltage takes the form of a succession of transient damped oscillations at frequencies of about 100 kc/s to 200 kc/s. The generators normally used for testing are Tesla coils. The combination of high voltage and high frequency, however, restricts the total capacitance and therefore limits the number of porcelain insulators which can be tested simultaneously by a Tesla coil. For this reason, acting on a proposal put forward by Messrs. Merz and McLellan, consulting engineers, the B.T.H. research laboratory engineered a new form of generator for the production testing of insulators.

This generator is designed for applying high transient oscillatory voltages simultaneously to a number of porcelain insulators, subjecting them in the process to high-energy oscillatory transients. In the generator there are eight condensers which are charged in parallel and discharged in series as in the Marx circuit. But whereas the normal Marx circuit produces a single impulse, the condensers in the new generator are charged and discharged recurrently, fifty times per second, through an inductance, so that the voltage transients applied to the insulators are oscillatory. At full rating the mean power input to the generator is about 22kW, about half of which is available for dissipation at the porcelain insulators in the form of corona and other losses.

§ ibid. November 11, 1955, pages 690-693.

The transient generator, part of which can be seen in Fig. 8, is 17ft high and consists of five columns, two of which are made up of condensers, two of inductances and the fifth of spark gaps. The central column seen in our illustration contains the spark gaps and the right-hand and left-hand columns consist of condensers. One of the two inductance columns is partly hidden behind the central spark gap column and in front of the latter is the mechanical drive for spark gap adjustment.

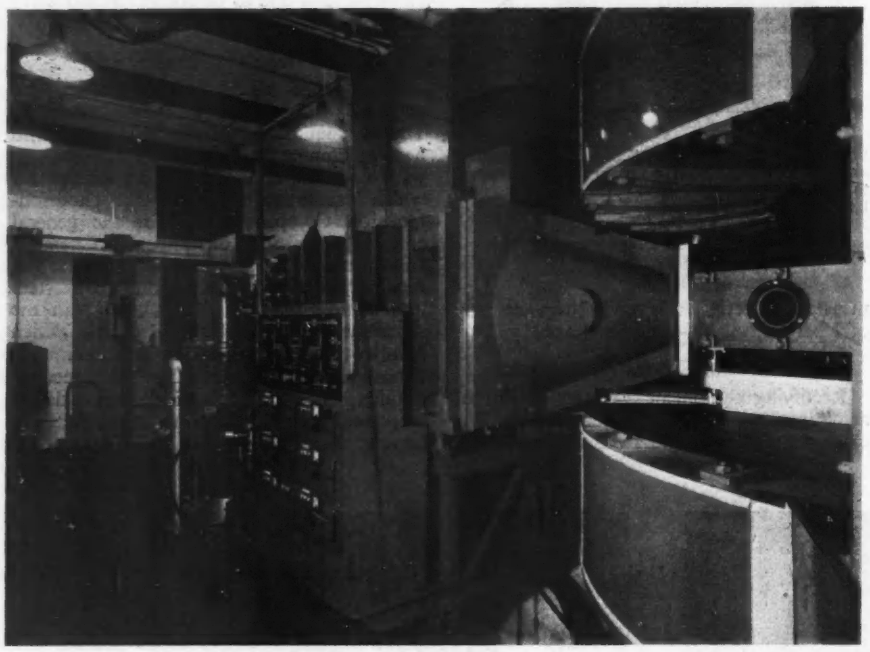


Fig. 9—Pumping equipment for a 45in cyclotron installed in the Hammersmith Hospital. Part of the cyclotron can be seen on the extreme right. In preliminary trials an internal beam of 30MeV alpha-particles has been obtained

Particle Accelerators

Under the sponsorship of the Medical Research Council considerable progress has been made in recent years with the installation in hospitals of particle accelerators for deep therapy and research. Some of them, including a linear accelerator at Hammersmith Hospital, and a variety of equipments at the Christie Research Centre, near Manchester, have already been referred to in our columns.

One of the more recent installations is that of a cyclotron at Hammersmith Hospital. It is said to be the first cyclotron to be installed in a hospital and, subject to proving tests, it should be a useful instrument in medical research and therapy, because of its ability to produce neutrons, charged particle radiations and radioactive isotopes. In preliminary trials with this cyclotron an internal beam of 30MeV alpha particles has been obtained and beam currents up to 750 microamperes of singly charged molecular hydrogen ions have been measured at a 6in radius.

The cyclotron was described in our issue of June 17, 1955 (pages 846–47). Briefly, the cyclotron is a 45in machine, the magnet system consisting of a rectangular steel yoke forming a "window," part of which is occupied by the pole pieces, the magnetising coils, the vacuum chamber and the "dee"-shaped electrode system. The coils are water cooled and are built up of rectangular section aluminium tube. Each coil consists of 408 turns, and carries a full-load current of 560A, giving a maximum field strength of 17 kilogauss across a total effective gap of 8in. Each pole consists of two flat circular discs of 57in diameter, and the pole faces are parallel and concentric within 0·0035in and 0·005in respectively.

The ion source is a modified version of that developed at Washington University, using a hooded hairpin filament set vertically, a method which was introduced recently by Rossi at the University of California. The radio-frequency system operates at a fixed frequency of 11,286 Mc/s and is designed for an output of 75kW, being based on a crystal-controlled FT300 transmitter made by the Federal Telephone and Radio Company. The vacuum pumping system, part of which can be seen in Fig. 9, consists of two 16in "BAR" diffusion pumps, backed by two Kinney mechanical pumps with a total capacity of 200 cubic feet per minute.

The Hammersmith cyclotron is installed above ground in a chamber 44ft long by 20ft

wide by 13ft high, with 6ft concrete walls and roof, for shielding. The floor is of 3ft 6in by 2ft concrete slabs and below it is a basement containing cable and pipe runs.

An interesting piece of equipment for atomic research is the proton linear accelerator of 0·5 to 50MeV, which is being built by Metropolitan-Vickers Electrical Company, Ltd., in collaboration with the U.K. Atomic Energy Authority. It is intended for installation in the Atomic Energy Research Establishment at Harwell, where it will form the first section (described in the first annual report of the U.K.A.E.A. as the "pilot section") of a 600MeV accelerator.

This proton accelerator will consist of three resonant cavities, 20ft, 40ft and 40ft long, respectively. In the first 20ft cavity protons from an injector will be accelerated to an energy of 10MeV. Power for this process will be provided by triode amplifiers driven at a controlled frequency, using valves specially developed for this duty by the U.K.A.E.A. Grid focusing will be used in the first cavity, but, in the rest of the accelerator, magnetic alternating gradient focusing will be used to extract a higher current beam. In the latter method of focusing a quadripolar lens is included inside each drift tube and these lenses are so arranged that focusing in one plane and defocusing in a plane at right angles are interchanged on alternate drift tubes. This system produces overall focusing in the way that is now used for large synchrotrons.

To acclerate protons to an energy of 50MeV r.f. power will be applied to each cavity in pulses of 400 microsecond duration at a maximum recurrence rate of 50 per second. The injector is to supply a peak current of 5mA at 0·5MeV and, as 0·5mA is expected to be trapped in phase and accelerated in the machine, a high output may be anticipated.

Radio Communications

An important extension to the Rugby radio station was officially opened on July 28, 1955, after the old station, with various modifications and additions, had provided radio communication services continuously for nearly thirty years. It may be recalled that the original Rugby radio station began operation on January 1, 1926, for the transmission of telegraph messages on a wavelength of 18,750m. Later, it was enlarged to include telephone and telegraph transmitters working in the 10–100m waveband. In the past twenty-five years additional transmitters have been installed at other G.P.O. stations to meet the growing demand for radio communication services and, in particular, a new station was built in Wales during the war. More recently, the need became urgent for a further expansion of radio-telephone, telegraph and picture services to various parts of the world. Accordingly, it was decided to build a new radio station on a 700-acre site adjoining the 900-acre site of the existing building.

The new station accommodates twenty-eight high-frequency transmitters with their auxiliary equipment. These transmitters are installed in three transmitter halls which radiate from a central control room (Fig. 10).

The transmitters work on various frequencies and direct-switching facilities are provided for connecting any transmitter to any one of six aerials by operating a switch at the control desk. By adopting a non-resonant design the total number of aerials needed is kept to a minimum and the switching arrangements are simplified. Connection between the aerials and the station building is made by high-voltage open-wire transmission lines; inside the building itself balanced coaxial feeders are used.

Two kinds of drive unit are installed to translate the signals arriving by land-line from London into forms suitable for application to the transmitters. One is for telephony, multi-channel telegraphy, and picture transmission, the other for various methods of telegraphy. These drive units deliver low-power signals of 3·1 Mc/s to the transmitters, all of which are of the same design. Each drive unit includes a monitoring receiver which automatically compares the signals arriving at the station with those leaving the transmitter, and indicates any falling off in quality at the control desk. Low-power signals from the drive units are converted by the transmitters into any required frequency between 4 and 27·5 Mc/s and amplified some 20kW to 30kW, before being delivered to the aerial feeder system. By preserving very accurately the form of the signals, each transmitter can deal with several independent signals without appreciable interaction. In this way, for example, four telephone channels, or two telephone channels and six telegraph channels can be handled by one transmitter.

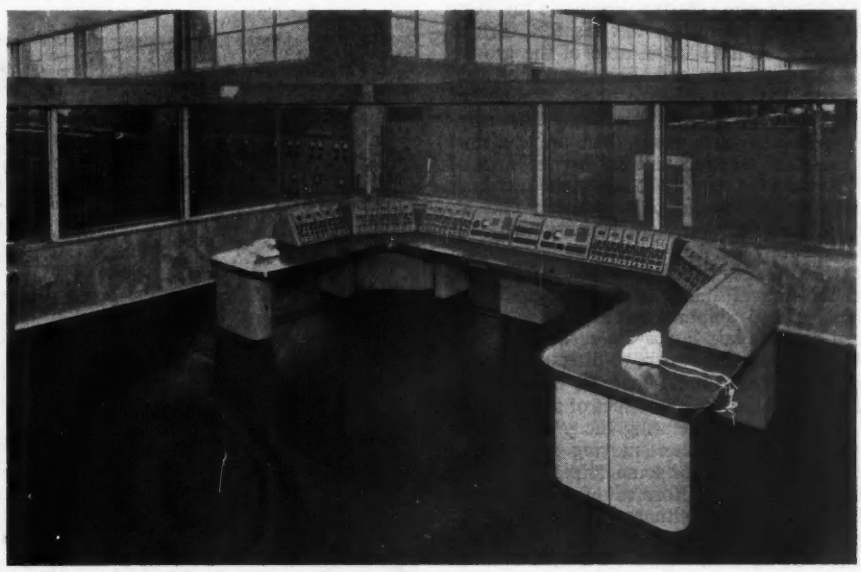


Fig. 10—Central control position in the new radio station at Rugby. At the desk are concentrated the control panels for the transmitters which are installed in three rooms radiating from the control room

The overall design of the station was done by the engineering department of the G.P.O. The transmitters, aerial switches and the central control system were designed to G.P.O. specifications by Marconi's Wireless Telegraph Company, Ltd.

An interesting development in commercial v.h.f. communications was announced during 1955 when Pye, Ltd., of Cambridge, demonstrated the "Ranger" mobile radiotelephone set which is designed to operate on channel spacings as close as 25 kc/s over its whole frequency range of 25 to 174 Mc/s. This close spacing should permit more frequency channels to be allocated, making better use of the available frequency bands.

The mobile transmitter has an r.f. output of 4W to 6W and consists of a crystal oscillator followed by three multipliers and a power amplifier, the modulator consisting of a phase-splitter and push-pull modulator. The crystal frequencies are between 6·25 and 12·5 Mc/s and the total drift from all causes is stated to be less than ±0·002 per cent.

A high-performance, double-superheterodyne circuit is used for the receiver, special attention having been paid to reduction of cross-modulation and inter-modulation interference. The total drift from all causes is given as less than ±0·0025 per cent.

A steel case, measuring 9¾in wide by 14in deep by 5½in high encloses the mobile transmitter, receiver and power supply assembly.

V.H.F. Broadcast Transmissions

The first stage in the B.B.C.'s scheme for providing Britain with a v.h.f. broadcasting service, giving extended coverage, reduced interference and improved reception quality, was completed on May 2nd, when the Postmaster-General opened the Wrotham v.h.f. transmitting station†. It may be recalled that for some years the service given by the existing medium and long-wave broadcasting stations operated by the B.B.C. has been restricted by the limited number of wavelengths available for broadcasting in Great Britain. Furthermore, interference from foreign stations has seriously reduced the coverage, particularly of the Home Service.

To study the possibilities of remedying these defects by v.h.f. broadcasting, the B.B.C. established an experimental station at Wrotham, Kent, equipped with a 25kW frequency-modulated (F.M.) transmitter and an 18kW amplitude modulated (A.M.) transmitter (both Marconi equipments). From June, 1950, until March, 1955, test transmissions were radiated on F.M. and A.M. signals. From these experiments it was decided to use F.M. for sound broadcasting in the v.h.f. band, and a scheme was formulated by the B.B.C. whereby about 98 per cent of the population could be reached by a frequency-modulated v.h.f. service. The scheme was divided into two stages. Stage I, covering the main centres of population (83 per cent of the total) as quickly as possible, is to consist of five high-power and five medium-power stations. It was approved by H.M. Postmaster-General in July, 1954, work is now in hand and the station at Wrotham represents the first step in the implementation of the project. The remaining stations in stage I are at Pontop Pike (N.E. England) Divis (N. Ireland), and Meldrum (N.E. Scotland), scheduled for completion in 1955, and Norwich, Dartmoor, Holme Moss, Sutton Coldfield and West Wales, to be completed this year. The second stage of the scheme will require about sixteen more stations.

† The Engineer, May 6, 1955, pages 626–627.

Shipbuilding and Marine Engineering in 1955

No. II—(*Continued from page* 18, *January 6th*)

Research and Development

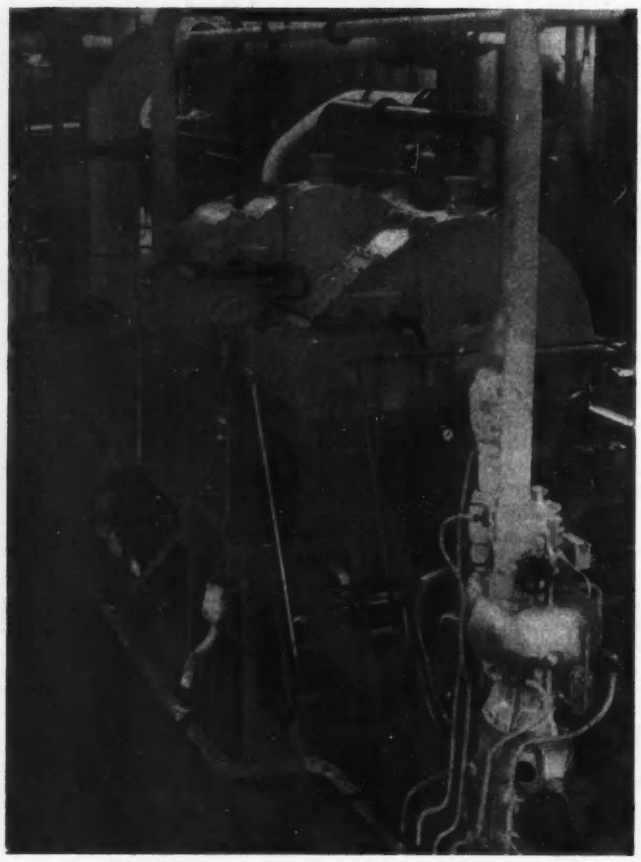
THE British Shipbuilding Research Association, under the direction of Dr. S. L. Smith, completed a very busy year, during which good progress was made in all aspects of the work and much useful design data was produced for the benefit of the member companies. One item of particular importance was the announcement that the Association was actively studying the problems of atomic energy.

During recent years there have been clear indications of the growing desire of the Western European nations to develop their own research associations based on the British model and the formation of the Research Committee of the Society of Naval Architects and Marine Engineers in New York is of interest in this respect. British shipbuilders have taken note of the growth of this movement and the existence of such bodies has strengthened their support of their own research organisation. That shipowners also have more than an academic interest in research and are appreciative of the vital need rapidly to apply the advances in technical knowledge to practical ends so as to gain the maximum benefits was made apparent by Mr. A. I. Anderson, the president of the Chamber of Shipping, in a speech made at the annual dinner of the Glasgow Shipowners' and Shipbrokers' Benevolent Association. He said it was the business of shipbuilders and shipowners to direct the results of research into those channels which would most influence the economics of shipping.

It was revealed during the year that the Association had been studying the problem of atomic energy for some considerable time and was closely informed of developments in this field, the ultimate object being the possible application of such energy to merchant ships. Facilities for the investigations were provided by the United Kingdom Atomic Energy Authority and it was stated that a preliminary assessment of the work had resulted in the Association sending a team to Harwell to make a more detailed study of marine reactors. Sir Wilfrid Ayre is the chairman of the special technical committee concerned with this work. With the completion of the submarine "Nautilus" it is reasonable to assume that a reactor can be built and that shielding problems can be solved; however, merchant ships are the concern of the research team and it has been studying possibilities on a technical and economic basis.

As in previous years, several research schemes reached a stage when a report could be prepared and a total of thirty-four research reports were circulated to members who also received eight technical memoranda, while the results of several items of research were incorporated in papers read before certain of the technical societies.

Almost from the beginning one item in the Association's programme has been experimental work on the methodical series using models of ships of ocean-going category. This work has involved investigations into the effect of varying the hull form and last year the work was continued, mainly at the N.P.L., and the series was extended to include models having a block coefficient within the range 0·80 to 0·875. Progress was also made in the research work on tugs, trawlers, and other specialised craft. Also in the field of hydrodynamics consideration was given to the problem of hydraulic flumes, and the Engineering Department at Cambridge University investigated the possibility of developing a small-scale prototype hydraulic flume. This work, which was completed during the year, demonstrated, on the model scale, that it was possible for such equipment to function, and the results were published in two papers presented to the Royal Society, with the title "Experiments on the Flow of Water from a Reservoir Through an Open Horizontal Channel." Part I was given by A. M. Binney, P. O. A. L. Davies and J. C. Orkney, and entitled "The Production of a Uniform Stream," and Part II, "The Formation of Hydraulic Jumps," by A. M. Binney and J. C. Orkney.



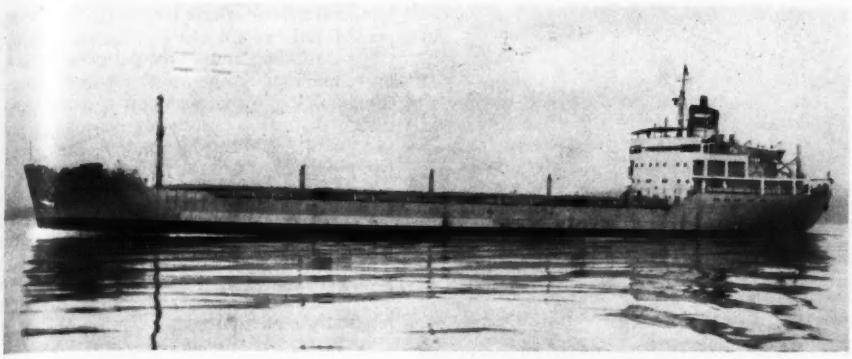
Merchant ship gear testing rig employing circulation power

Hull roughness continued to fill an important position in the research programme and consideration was given to the extent to which improving the smoothness of a ship's hull is beneficial in reducing the skin friction resistance. The important part played by the condition of the hull surface in controlling the amount of skin friction had been clearly demonstrated from the results of the "Lucy Ashton" experiments carried out by B.S.R.A. For part of the work a plank was used and the investigations, together with the results, were described by J. F. Allan and R. S. Cutland in a paper read before the Institution of Engineers and Shipbuilders in Scotland and entitled "Investigation of the Resistance of an 18ft Plank." Other fundamental work, using pipes, was put in hand at Cambridge University by the Association.

At the N.P.L. a number of wind tunnel tests were carried out as part of a programme of research into the effect on wind resistance of the hull and superstructure. Models of two cargo liners and an oil tanker with varying amounts of freeboard were tested, and the resulting design and performance data were issued as a report to members. Further work was put in hand with regard to wind effect upon a passenger liner. Reference has been made already to the "Lucy Ashton" experiments and at the spring meetings of the Institution of Naval Architects the final paper of the series was presented. It was read by S. Livingstone Smith, entitled "B.S.R.A. Resistance Experiments on the 'Lucy Ashton,'" and an abstract of the paper appeared in the April 15th issue of The Engineer. The paper was concerned with miscellaneous investigations, which included the effects of fouling on resistance, acceleration and retardation trials, pitot traverses in the ship's frictional belt, giving velocity distribution, and an appraisal of the principal findings from the experiments.

Work on model scale, subsequently checked on full scale, was continued during the year in the constant effort to expand knowledge of ship structures. Research into the behaviour of structures at sea was carried out by B.S.R.A. with the collaboration of Lloyd's Register of Shipping. In this particular section of the work the question of providing staff to make long voyages for the purpose of taking readings has been a matter of concern. To overcome this difficulty endeavours have been made to develop autographic recording and statistical strain gauges at the Association's small laboratory and workshop at Palmers Hill, Sunderland. Research into the question of loads, stresses and deflection in ship structures was actively pursued during the year and J. C. Chapman, and S. R. Sparkes, who read a paper entitled "Experiments on Box Girders: Some Contributions to the Theory of Ships' Structures," before the Institution of Engineers and Shipbuilders in Scotland. The work was done at the Imperial College of Science and Technology, and with regard to the question of the interaction between superstructure and main hull the College subjected a box girder with superstructure to bending and shearing forces, and two reports on the results were issued to members.

Attention continued to be given to the performance of launching greases; measurements were taken at a number of launches and certain tests in the laboratory were completed. A programme was formulated for a further series of tests to be carried



The bauxite carrier S.S. "Discoverer," built by the Burntisland Shipbuilding Company, Ltd., for the Pan-Ore Steamship Company Inc., incorporates special characteristics required for a shuttle service between Suriname and Trinidad. The length between perpendiculars is 425ft, breadth moulded is 60ft, depth moulded is 29ft 6in, and a deadweight of 7950 tons is carried on a draught of 20ft 6in. Two long hopper shaped holds, between wing water ballast tanks, carry the bauxite cargo, which is loaded and discharged by shore equipment. The ship is propelled at 12 knots by a set of double-reduction geared turbines, built by David Rowan and Co., Ltd., which develop 3300 s.h.p. at 112 propeller r.p.m. and take steam at 400 lb per square inch and 725 deg. Fah. from two Babcock and Wilcox water-tube boilers

out under shipyard conditions for the purpose of determining the coefficient of static friction. At Glengarnock work proceeded on full-scale ship structural components in collaboration with Lloyd's Register, and a report on the bending strength of deep web girders for plain and corrugated bulkheads was prepared for the members. A report was also issued on work which had been carried out for the Association elsewhere, including research at Cambridge University on clamped rectangular flat plates subjected to normal and compressive edge loads, and the full-scale bracket investigations at Birmingham University. The research scheme at Bristol University concerned aluminium alloys and the possibilities of their employment in ship construction, and the results of the investigation were embodied in a paper, with the title "An Analysis of the Behaviour of Riveted Joints in Aluminium Alloy Ships' Plating," which was given by A. R. Flint to the North East Coast Institution of Engineers and Shipbuilders.

In the field of machinery research the various items on the programme have been the responsibility of sub-committees of the main machinery committee. One item which was investigated jointly with the British Ceramics Research Association was concerned with the question of brick and brick bolt mats able to withstand high temperatures and prevent loss of heat in high-pressure boilers. A report dealing with operating temperature conditions was produced and further work given consideration.

The nuisance of funnel smoke descending on to decks was again the subject of investigation and the results of experiments on models in a wind tunnel were confirmed by readings taken at sea. As a result of this verification of the model techniques used, a further series of tests were made and a report produced giving observations of the turbulent zone above the ship superstructure with the comparative wind tunnel results. Another research scheme concerned the corrosion, sooting-up and burning out of air heaters, and a survey of the problem was made and issued before undertaking a field survey. A review of material for superheater tubes and supports was also prepared.

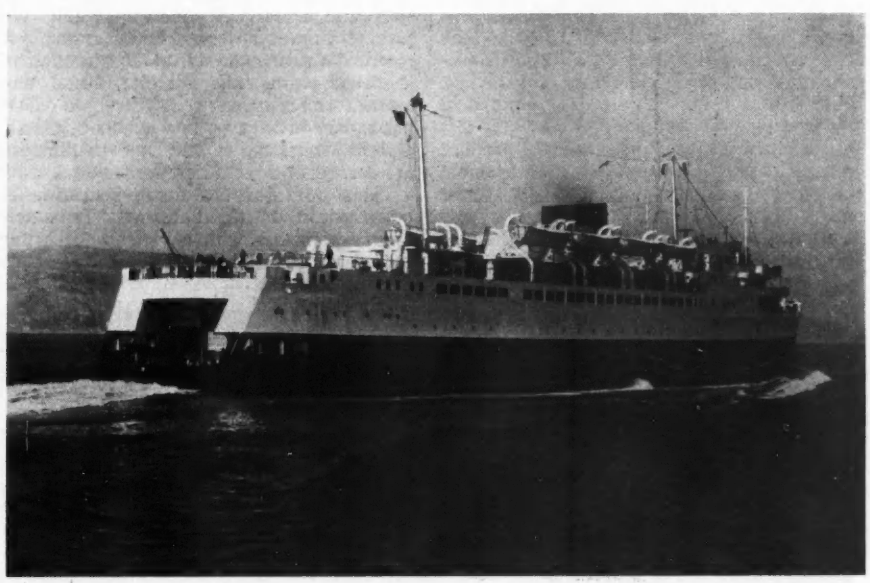
Various aspects of internal combustion engine research were actively pursued during the year and the failure of built-up crankshafts was one of the items under review at the Royal Technical College, Glasgow, where a new fluctuating load machine, to assist the experimental work, was completed and tested. A paper describing and supplementing the experiments on oscillating bearings and entitled "Some Experiments on Oscillating Bearings" was presented by F. T. Barwell, A. A. Milne, and J. S. Wheeler, before the Institution of Engineers and Shipbuilders in Scotland.

The important problem of the causes of crankcase explosions was further examined and the investigations were the subject of a paper which dealt with the combustion characteristics of lubricating oil mists. This paper, entitled "Crankcase Explosions in Marine Engines," was read before the Institute of Marine Engineers on April 25th by J. H. Burgoyne and Professor D. M. Newitt. The Association, in collaboration with the Graviner Manufacturing Company, Ltd., successfully developed a device for detecting the presence of oil mist which gives visible and audible warning of the presence of a dangerous concentration. Sea trials under tropical conditions were carried out and two reports were issued to members, one of which concerned non-inflammable lubricating oils in marine engines, while the other discussed investigations into explosion relief.

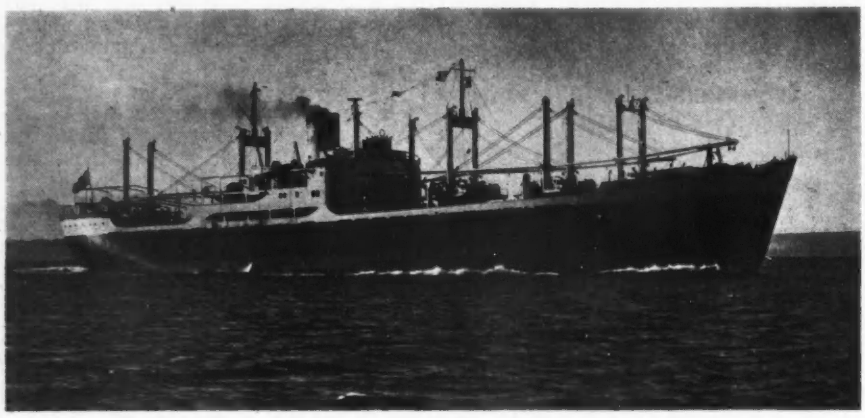
At the conclusion of research into the stresses that occur in combustion chamber parts, including work on the physical and mechanical constants of the material which affect thermal stresses, the results were recorded in a paper entitled "An Investigation of the Factors Contributing to the Failure of Diesel Engine Pistons and Cylinder Covers," which was read before the North East Coast Institution of Engineers and Shipbuilders by D. Fitzgeorge and J. A. Pope. Another item which concerned materials was an investigation into the distribution of load along nuts and the fatigue of bolts and studs. The influence on the fatigue strength of large bolts of the accuracy of screw-cutting methods formed the subject of a report, while another report received by the members gave the result of an investigation into the effect of thread rolling on the fatigue strength of bolts. Both these reports dealt with matters having a bearing on shop practice and as such recorded data of practical interest to marine engine builders.

During the year the accelerated corrosion tests designed to provide information concerning the corrosion of mild steel tubes in Scotch boilers were continued at the Chemical Research Laboratory, and a report was issued which dealt with the effect of the copper content of the steel. Questions relating to propeller tailshafts received attention and as a preliminary a survey was made of the existing information and current practice in their design, manufacture and assembly. Stemming from this survey, tests were commenced on a 3in model assembly.

The present main target of the Association in the field of vibration is to endeavour to reduce this nuisance to a minimum by investigating troubles at their source, and under working conditions, in order to devise and advise upon remedial action. Such work was pursued during the year as a contribution towards building up a fund of information



The passenger, train and car ferry "Princess of Vancouver" operates between Vancouver and Nanaimo, in the British Columbia Coast Steamship Service of the Canadian Pacific Railway Company. The ship, which has a service speed of 15½ knots, has accommodation for 800 passengers and can carry twenty-eight box cars or 115 motor-cars on the main deck. Alexander Stephen and Sons, Ltd., were the builders, and the main particulars are: length between perpendiculars, 388ft; breadth moulded 63ft; depth moulded to main deck 19ft 6in; draught loaded, 14ft 9½in. Berthing and unberthing is assisted by a Voith Schneider propeller mounted in an athwartship tunnel forward. The main propelling machinery consists of four Mark B4AUM7 four-stroke, pressure-charged diesel engines, built by the National Gas and Oil Engine Company, Ltd. The engines, each of which develops 1575 b.h.p. at 333 r.p.m., drive two propeller shafts at 200 r.p.m. through Hindmarch/M.W.D. oil-operated, twin-input, reverse reduction gearboxes and Vulcan-Sinclair fluid couplings



Newsprint carrier S.S. "Margaret Bowater"

upon which to base more fundamental and theoretical investigations so that accurate prediction of hull vibration frequencies may be made at the design stage. In addition to the early trouble shooting investigations full-scale tests using an exciter were carried out, and the construction completed of a new and lighter exciter. Certain model experiments were also undertaken. Reports on the work were circulated to members.

Last year, as in previous years, the staff of the Association attended a number of measured mile trials and made voyages in ships as part of the long-term investigation into the performance of ships both as regards hull and machinery. The instrumentation aspect of the work continued to engage attention and pitometer logs were fitted to ships in an endeavour to obtain data on service performance. Records from ships in service were received and analysed, and in a number of ways B.S.R.A. is trying to link measured mile performance and service performance. The significant part played by the degree of hull roughness has been amply demonstrated, and, in view of this, inspection of the hull and the recording of surface roughness were carried out as a standard part of the trials procedure whenever opportunity availed. At the N.P.L. the complementary information to the performance data was obtained from running models, and both sets of results were incorporated in the investigation of ship model correlation.

Technical research schemes to produce reliable data to be used in the improvement in the design of ships and machinery are the main object of the B.S.R.A. However, this work is supplemented by the Association's intelligence section, which culls information from sources all over the world and so enables the technical staff to be kept in touch with the latest technical advances. The information so garnered finds its way into the hands of the members by way of the monthly journal and through the Association's inquiry service.

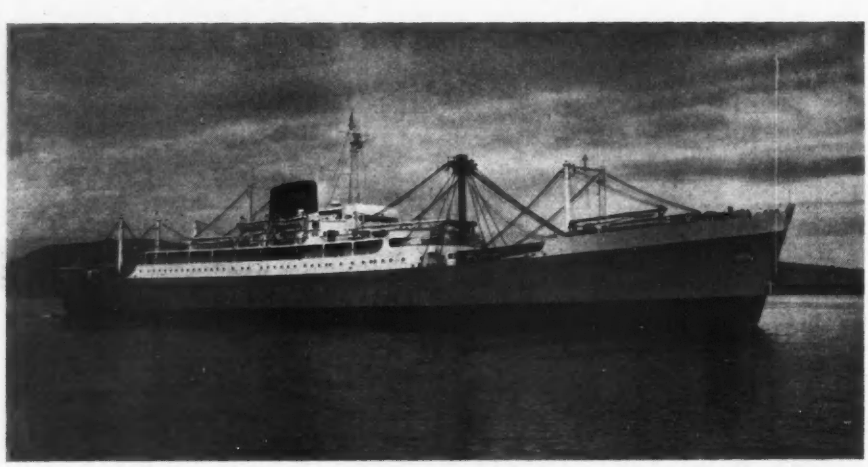
Progress in many fundamental and technological investigations was made by the Parsons and Marine Engineering Turbine Research and Development Association, under its director, Dr. T. W. F. Brown, according to the latest report available concerning the work at that research establishment. During the period referred to in the report a new office block and workshop were commissioned. Ten research reports were issued to member firms and twenty contract reports prepared, fifteen for the Admiralty and five for individual firms, and several papers were read before the technical institutions by members of the staff. Some sixty new design inquiries were handled and resulted in the placing of some new orders, while many repeat orders of successful designs were received. A large number of trials of high-temperature, and high-pressure machinery were attended by the staff and questions concerning hull and turbine vibration were checked at sea. A recent development was the construction of a double-casing, high-pressure ahead and astern turbine, which accepts steam at 575 lb per square inch gauge and at 940 deg. Fah. and in which the nozzles and diaphragms are carried in a separate cylinder.

Plans went forward for a heat transfer investigation on the Pametrada separately fired superheater with a view to collecting data for a superheater to operate at steam temperatures of over 1000 deg. Fah. Repeated failures of the driving turbine first stage shrouding limited the period of running of the high-temperature steam turbine (Pamela), but work went on and consistent casing distortion results were obtained and successful modifications made to the exhaust gas piping expansion arrangements. A gear noise test rig was completed and noise measurements made on turbo blowers and silencers, and a turbo-alternator. Progress was made in the work on non-condensable gases in steam, and the position attained where steam samples from boilers and turbines could be analysed.

A rotor balancing machine with an accuracy of ± 5 deg. and a reponse to pedestal vibrations from 0·0001in/sec was made up and remote control developed for the mechanically tuned system. A water extraction apparatus and a dryness fraction meter were completed and proving tests run, while two trials were concluded in the turbine blade research scheme on a six-blade batch. An analysis of the results indicated that the method of assessing the ratio of vibrational and steady bending stresses is almost correct. A summary of the results of the condenser test programme was issued: it took note of the high temperature of the air stream mixture extracted by the air ejector, the high heat loading of the tubes inside the air tent, the reasonable regeneration and uniformity of the circulating water flow and the general agreement of heat distribution with predictions.

A report on the hot and cold oil trials on the "Imo" pump was completed and another on the testing of a flexible steam pipe, while further work was carried out on a new form of blade root suitable for brazed segmental blading on gashed rotors. In the single-stage air turbine research scheme a high-speed ball bearing satisfactorily replaced the air bearing and the Tufnol half coupling was statically loaded up to twice the air turbine torque. Work was carried out to determine an impulse blade form suitable for supersonic flow and preliminary results on three blade forms were made available. Further test rubs were carried out using a mild steel disc and brass gland strips and a new rub operating cam was made. A guarding valve for sensitive vacuum gauges was operating under service conditions to prove reliability and had proved successful to date. Wooden models of high-temperature, high-pressure steam valves were air tested and losses measured, and useful data were obtained concerning valve proportions and shape.

Contract reports dealing with the trials, up to 26,000 h.p., of the A.V.G.R.A. 12,000 h.p. back-to-back gears were completed or in preparation, and a set of 8500 h.p. gears was tested to destruction, a test pinion tooth breaking at a loading of $522K$, the equivalent gear loading K being 386. Trials of the first set of Pametrada test gears were carried out in the merchant ship gear-testing rig and other gears in other materials were in course of manufacture. Investigations into the performance of thin shell journal bearings were continued, including one having a length/diameter ratio of one-third. Experiments to produce a bearing which, in the event of a lubricating oil supply failure, would support the rotor without damage to the journal, while the turbine runs down, resulted in the development of a bearing using a copper-tin sinter as a safety layer. This has proved satisfactory and an interim report was issued. Tests on an 8in model of a type "A" astern converter indicated that the scale did not affect efficiency and demonstrated the value of using models for develop-



Twin-screw insulated motorship "Port Melbourne"

ment work. Testing and modification was carried out on a model of a type "C" converter and a maximum efficiency of 64 per cent was achieved.

Cargo-Passenger and Cargo Ships

Two liners completed during the year were illustrated in our issue of January 6th, and a number of cargo-passenger ships were shown in Plate 5 of the same issue. Other cargo-passenger ships which went into service in 1955 include the M.V. "Owerri," which Harland and Wolff, Ltd., constructed at Belfast for Elder Dempster Lines, Ltd. This ship has a length between perpendiculars of 425ft, a breadth moulded of 62ft and a depth moulded to shelter deck of 34ft, and carries twelve passengers on the bridge deck in single and double-berth cabins. There are four cargo holds and a deep tank and the cargo is handled by seventeen derricks, with lifts ranging from 3 tons to 12 tons, and two heavy derricks, one to lift 50 tons and the other 30 tons, all operated by electric winches. Power for the auxiliaries is supplied by four 125kW diesel-driven generators, and the ship is propelled by a two-stroke, single-acting, opposed-piston oil engine having five cylinders of 620mm diameter by 1870mm combined stroke.

William Denny and Brothers, Ltd., delivered to the Bowater Steamship Company, Ltd., the "Margaret Bowater," which we illustrate, and which has been designed for the carriage of newsprint on the Atlantic Coast of North America and the Gulf of Mexico. About 5000 long tons of newsprint rolls can be carried on a draught of 22ft 6in, while the maximum deadweight is 8400 tons on 26ft 6in draught. The main dimensions are length overall 419ft, moulded breadth 58ft 6in, moulded depth to upper deck 35ft 6in, and speed 15 knots. Fourteen 5-ton and two 10-ton derricks, operated by steam winches, serve the six hatches, which are fitted with MacGregor hatch covers, and electric power requirements are met by three 60kW steam-driven generating sets. Propulsion is by a set of single reduction geared turbines, which develop 4700 s.h.p. at 90 propeller r.p.m., and take steam at 250 lb per square inch at 650 deg. Fah., desuperheated to 450 deg. Fah. from two oil-fired Foster Wheeler boilers.

Early in the year the Prince Line, Ltd., took delivery from the Burntisland Shipbuilding Company, Ltd., of the cargo liner "Black Prince," which has accommodation for twelve passengers in single-berth cabins, carrying a deadweight of 4900 tons on a draught of 21ft 9½in, and the following dimensions: length between perpendiculars 345ft, breadth moulded 52ft 7in, and depth moulded to shelter deck 32ft 4in. The cargo is handled by ten 5-ton and two 10-ton derricks and one 25-ton heavy lift derrick. Steam deck machinery is fitted and the ship is propelled by a Hawthorn-Doxford opposed-piston oil engine having four cylinders of 600mm diameter by 2320mm combined stroke and developing 3300 b.h.p. at 110 r.p.m.

One of our illustrations shows the twin-screw cargo vessel "Port Melbourne," which was handed over to the Port Line, Ltd., by Harland and Wolff, Ltd., and which has a length overall of 533ft by 70ft breadth moulded by 42ft depth moulded to the upper deck. Single and double-berth cabins are arranged in the boat deckhouse for twelve passengers. There are three complete steel decks and six cargo holds, three of which are insulated, and the cargo handling equipment consists of one 70-ton, four 15-ton and ten 10-ton derricks, also one 3-ton and two 2-ton electric cranes. Four 360kW diesel-driven generators supply the power for the deck machinery, ship services and auxiliaries, while two composite boilers meet all steam requirements. Two single-acting, two-cycle, opposed-piston oil engines, arranged to burn heavy-grade fuel, are installed and each has six cylinders of 750mm diameter and 2000mm combined stroke. The "Port Sydney," a vessel of similar dimensions and 17 knots service speed, but powered with Wallsend-Doxford opposed-piston oil engines of 13,200 total b.h.p., was completed by Swan, Hunter and Wigham Richardson, Ltd. This company also delivered the M.V. "Cretic" to the Shaw, Savill and Albion Company, Ltd., and this ship, which has six holds, four being insulated, carries a deadweight of 11,480 tons at 17 knots on the following dimensions: length between perpendiculars 481ft, breadth moulded 69ft, depth moulded to upper deck 33ft 4½in, and load draught 30ft 4½in. Twenty-two 3-ton and 5-ton electric winches work in conjunction with a complement of 5-ton, 7-ton and 12-ton derricks and one 70-ton and one 25-ton heavy lift derricks. Power for propulsion purposes is developed by two six-cylinder Wallsend-Doxford oil engines of 12,860 total b.h.p. at 114 r.p.m., while two 480kW and two 200kW diesel-driven generators meet the demands for electrical power.

(To be continued)

Gas Turbines in 1955

No. I

WHILE it has long ago become clear that gas turbines have no chance of spectacular conquests, such as they gained in military aviation, in the many fields of commercial application, 1955 brought a number of significant pointers to an eventual success over the technological difficulties opposing their advance. It has been acknowledged that these difficulties can only be countered by costly refinement and, in some cases, complication.

A striking feature of last year was that among the new aircraft turbines many were variants of existing turbines.

At the Paris Aero Show there appeared the Bristol "Orpheus," a lightweight jet engine, with a thrust of 4850 lb in B. Or. 3 form, that will power various European interceptor fighters. Later there were published details of the Napier "Oryx," a single-shaft turbine, novel in having an auxiliary compressor to dilute the exhaust gas to a temperature acceptable for tip-jet-driven helicopters, and the Rolls-Royce "Conway" by-pass engine. The latter is a two-spool engine in which part of the air delivered by the low-pressure compressor by-passes the high-pressure stage and low-pressure turbine, being added to the exhaust gas to bring about a reduced efflux velocity and a more favourable energy balance at normal flight speeds. The "Conway" offers 13,000 lb thrust and fuel economy beyond that of established jet engines; consequently it is in demand for civil airliners, but, according to reports, the makers are embarrassed by there being no machine in which they can develop it on normal airline service. At the S.B.A.C. Exhibition at Farnborough it was demonstrated as a fifth engine on an Avro "Ashton." On the same occasion there appeared the de Havilland "Gyron"; type tested at 15,000 lb thrust, it is the most powerful British aero-engine, and is designed to operate with a considerable degree of ram compression. Also at Farnborough there was illustrated another solution to the helicopter power unit problem; the Napier Eland "N.El. 3," like the "Oryx," has a second compressor that does not supply the combustion chamber, but in this case it is driven by a fluid coupling. Thus the shaft power of the turbine can be directed either to the compressor to supply combustion air to burners at the rotor blade tips or to an airscrew to drive the aircraft with the rotor auto-rotating. This engine has been developed for the Fairey "Rotodyne," the combination of rotating aerofoils in horizontal and transverse planes having been demonstrated on the "Gyrodyne." The same manufacturer has developed a power unit with two turbines for the Bristol "191"; the "Gazelle" advertises its application to helicopter propulsion by running in a vertical attitude, with the turbines at the top and the power turbine shaft offering itself above the gearcase between the bifurcated exhaust ducts (Fig. 1). The pleasing symmetry of this arrangement is reflected in the absence of the fabricated tubular frame that unites compressor and turbine assemblies in the other small Napier engines.

The series-compressor layout, already accepted for industrial plant and the highest performance jet engines, has also been adopted by the leading exponents of turbo-prop engines. The Bristol "B.E. 25" and the Rolls-Royce "Tyne," compared to their predecessors, have acquired a compressor on the power turbine line and a separate compressor-driving turbine respectively. The

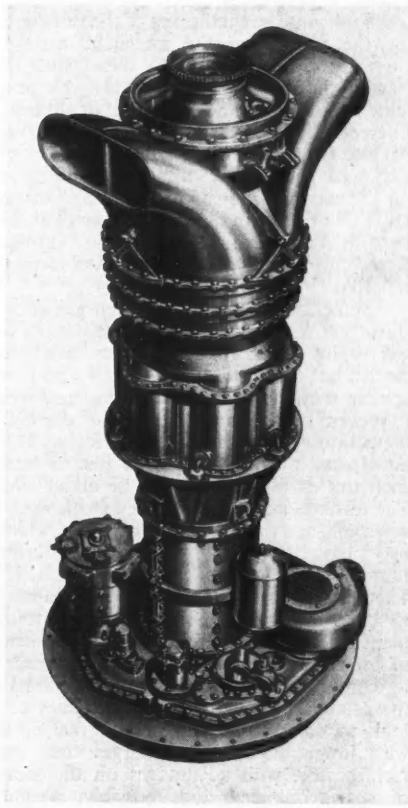


Fig. 1—An impression of the 1260 h.p. Napier "Gazelle" free-turbine engine that is being developed for the Bristol "191" helicopter

" B.E. 25," which first ran late in 1955 in the form of an aircraft power plant, is designed to circumvent the sensitivity of the gas turbine to ambient temperature, which demands expensive counter-measures from the fuel systems engineers and the aircraft operators. The new engine will have a characteristic reminiscent of the super-charged piston engine, in that it will deliver a constant rated power up to a certain altitude, above which the output falls off. Since there is, below the rated altitude, a reserve of power available, the nominal take-off power can be called upon at airfields in any conditions of temperature and barometric pressure. This sustained performance demands aerodynamic components resembling those of an 8000 h.p. engine for a 4000 h.p. rating, but reaps the reward of a reduction gear and propeller that are run at full power for a large proportion of the time. The difference between the power that can be passed through the gearing and that available at peak turbine temperature can be made available as compressed air for such purposes as flap blowing at take-off.

The compound engine has other virtues, such as ease of starting, higher attainable pressure ratios, and more rapid response in acceleration. To make the engine compact, however, increased turbine inlet temperatures are a necessity, and the " Tyne " has been equipped with cooled turbine blades. While it is unlikely, in view of the disproportionate relation between the weight of strategic material in the engine and the weight of fuel consumed, that advantage will be taken of this feature to economise on alloys, it is probable that, at some sacrifice in efficiency, a considerable increase in power will be available for short periods, as at take-off. In expecting a penalty in efficiency, we assume that the blades are air cooled ; we discuss developments in liquid cooling after reviewing progress in marine propulsion and auxiliary machinery.

An immense strengthening of the prospects for the turbine in the merchant marine, currently dominated by the diesel with its frugality in fuel, occurred early last year at a joint meeting of the Institute of Marine Engineers and the Institution of Naval Architects. Presenting an account of advanced gas turbine installations designed for the maximum saving in weight and space, Dr. T. W. F. Brown, Research Director at the Parsons and Marine Engineering Turbine Research and Development Association, reported :

" Sufficient experience has been gained to show that residual fuel can be used at sea in gas turbine machinery. Long runs have been carried out using additives and it would now appear that the cheapest additives required to prevent corrosion and fouling of the high temperature parts are in powder form. It is anticipated that the additional cost to treat each ton of residual oil will be about 10d. The turbines can . . . be washed (with water) when cold and the swallowing capacity, which may have been slightly reduced during running with additives, completely restored." The importance of the newly-found ability to burn low-grade fuel is that the turbine plant will not have to await the development of cooled high-temperature turbines in order to compete economically with the diesel ; the established 1250 deg. Fah. engines can look to comparable capital and fuel costs with lower maintenance charges than the reciprocator, with advantages on the score of space occupied and, possibly, weight. Thus, the main concern of the gas turbine proponents must be to go to sea, and Dr. Brown's paper dealt at some length with the problems of providing astern power and complete reliability. The transmission described was an advance upon the previous Pametrada pattern with a fluid coupling for ahead and a torque converter for astern propulsion on the primary pinion shaft of a double reduction gearbox, in that it also includes a direct drive clutch to suppress slip in sustained steaming ahead. Intriguing details of this clutch are that it needs no special high pressure oil supply, the acceleration field of a 5850 r.p.m. shaft energising it, and that sintered iron friction facings have been developed, with the advantage that any particles becoming detached can be extracted from the lubricant by a magnetic filter. To counter reluctance to undertake commercial operations with a new prime mover, the proposed 10,500 s.h.p. installation included duplicated main engines with triplicated ancillaries, while a smaller plant incorporated a " get-you-home " steam turbine mounted on the gearcase. As in a steamship, the turbine itself occupies little space : the 1200 h.p. example shown, with ahead and astern blading on the same disc, is little larger than the starter turbine. The turbine drives through a dog clutch to a shaft carried in eccentric bushes which allow its pinion to be engaged with the primary wheel. The steam can be supplied by two boilers, the waste heat boiler in the stack which burns oil for emergency and starting purposes, and a Scotch boiler installed for port use ; these boilers are normally employed to drive the auxiliaries, whose condenser exhausts the emergency turbine. Both fluid couplings would be drained to allow the primary pinion to idle when the " get-you-home " turbine is driving.

Convincing support for these proposals shortly followed, though not for their complex cycles, experience with reheat and direct-coupled axial compressors with intercooling being almost exclusive to Pametrada. At the Engineering, Marine and Welding Exhibition the British Thomson-Houston Company, Ltd., showed a model (Fig. 2) of a 5500 h.p. unit to replace the 1200 h.p. turbine and three diesels driving alternators aboard the tanker

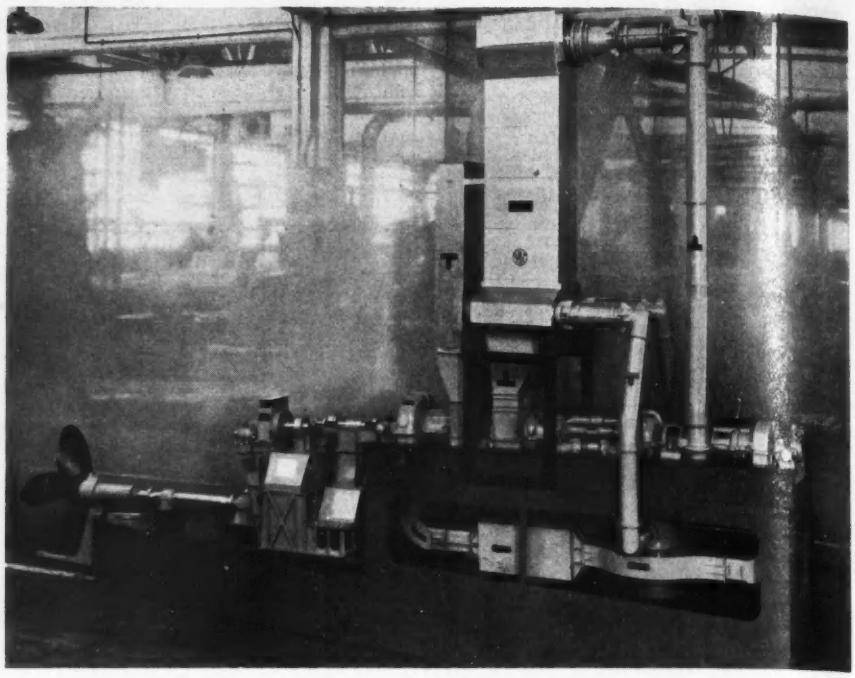


Fig. 2—A model of the " Auris " main propulsion gas turbine. Immediately below the heat exchanger is the l.p. turbine ; astern of that, the l.p. compressor, l.p. line turning motor, ahead coupling, primary pinion, astern converter, auxiliary coupling, reduction gears and alternator

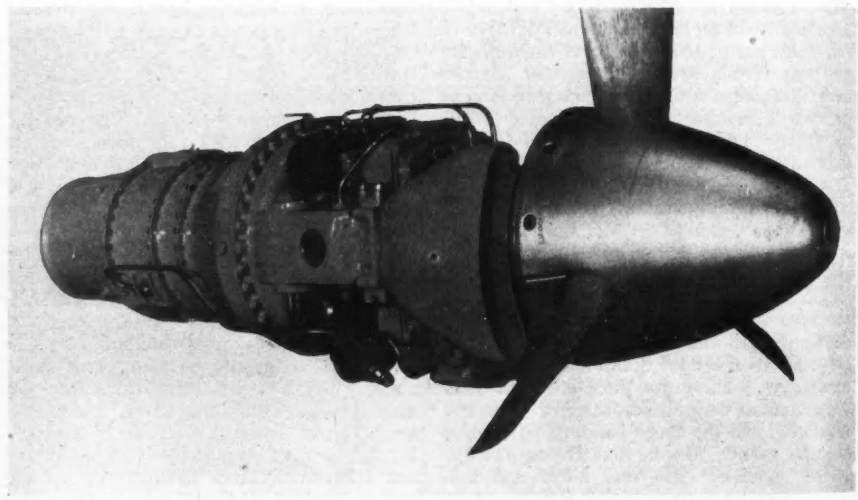


Fig. 3—The Turbomeca " Marcadau " single spool turbo-prop offers 475 s.h.p. and 64 lb thrust

"Auris," operated by the Shell Petroleum Company, Ltd. Shells' Marine Research and Development Department collaborated in the project, a straight-coupled two-compressor design with intercooling and heat exchange, the low pressure turbine driving through the hydraulic couplings to a single screw. Since a tanker makes heavy demands for auxiliary power for cargo handling, a third fluid coupling is keyed to the quill shaft to drive a 550kW alternator, either at sea or in port, thus exploiting the relative freedom from routine maintenance of turbine plants. At sea, the exhaust gas boiler runs a 200kW turbo-alternator. The emergency steam turbine is of 450 h.p. and will be supplied by an oil-fired boiler already aboard. A distinctive feature of the B.T.H. set is that it uses a refractory-lined combustion chamber, arranged in the up-draught attitude immediately below the h.p. turbine, with the intention that any detached fragments of refractory will be retained in the chamber by gravity. Except in the stand-by alternator mentioned below, commercial grades of boiler fuel will be used throughout: Shell report that Nimonic 80 blades have proved immune from corrosion in the "Auris," and they are tackling deposition difficulties on the same lines as Pametrada, namely, by using powdered additives such as kaolin. However, it is hoped to attain the ideal of one grain of kaolin in each fuel droplet more closely by using an ultra-sonic whistle than by the Pametrada technique of turbulent mixing, simple and effective on the macroscopic scale as that is. This microscopic mixing is regarded as the principal outstanding problem by Shell, and theoretical investigations do not appear simple. At this stage it may be observed that the "blotting paper" idea of soaking up molten vanadium oxides on granules of carbon left by incomplete combustion continues to prove difficult in achievement.

The stand by generator of the "Auris" will be a 120kW Allen gas turbine alternator. A 350kW set of this manufacture was also on display at Olympia, one of eight which are believed to be the first emergency sets to be installed in merchant vessels. Intended to be installed on the upper deck, with a minimum of trunking, the sets are self-contained, starting being by cordite cartridges and a 24V d.c. supply for the igniter. Hand and electric oil pumps are provided for priming the lubrication system before starting, and the fuel can be preheated before combustion. A single stage of Allen-Stoeckicht planetary gearing gives a 10 : 1 reduction from the turbine speed of 15,000 r.p.m.

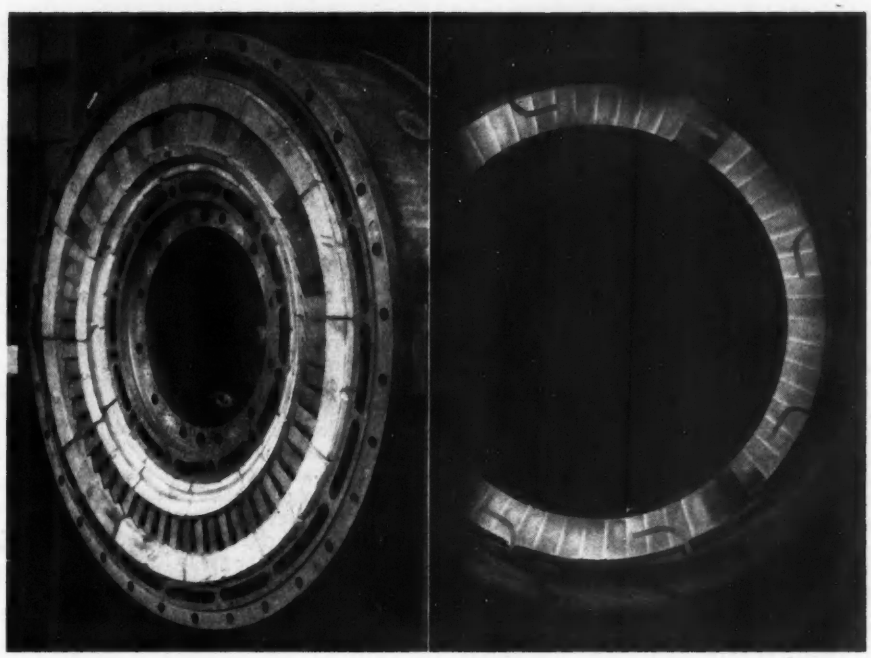


Fig. 5—The ceramic stator blades of the single stage experimental high temperature turbine at Pametrada are here seen freshly assembled in the refractory lined annulus, and (right) in a 2200 deg. Fah. gas stream

The self-contained set, being relatively small in air consumption and readily developed, is in the forefront of technical advance. The small Rover sets are now well established, coupled with fire-fighting pumps and electric alternators. A newcomer is the product of David Budworth, Ltd., at Harwich. This compact set has an annular combustion chamber and a vaporising burner; it is self-contained to the extent of needing no electric supply, initial ignition being from an external source and starting by hand. The governing is of the simplest, since the fuel delivery pressure is made equal to the maximum permitted compressor delivery pressure. A range of turbines that may be mentioned in this connection is that originated by M. Szydlowski and known by the name of Turboméca, which include fixed and free turbine shaft power engines, air bleed compressors, and turbo-jets. These engines, characterised by a low-pressure fuel system and atomisation from holes in the rotor shaft, are built on the light scantlings of aircraft practice, and are manufactured in England by Blackburn and General Aircraft, Ltd. Fig. 3 shows a single-turbine version with an airscrew fitted; the basic engine, the "Artouste," can be adapted to supply both shaft power and compressed air. The Turmo free-turbine engine has been developed into a 900 h.p. coupled engine pair for helicopter installation.

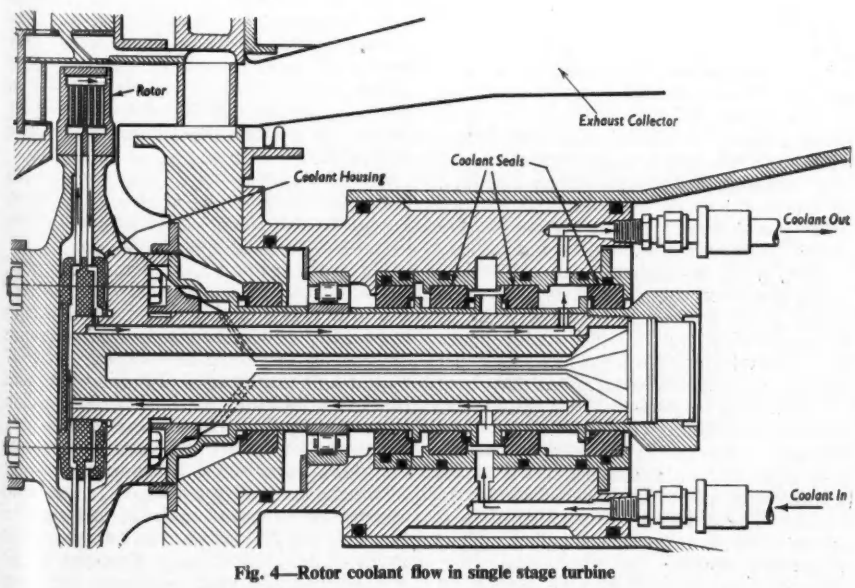


Fig. 4—Rotor coolant flow in single stage turbine

While engines such as these are not welcome in British aircraft as auxiliary power units, United States aircraft incorporate them both for use on the ground, including main engine starting, and as a stand-by in flight; particularly are they applied when constant frequency alternating current is required. Gas turbine power plants have become established for various purposes with the United States Armed Forces, and this has naturally led to rapid development. In process of producing a version of the "Jupiter" single-shaft unit with a minimum content of strategic materials and therefore using a three-stage liquid-cooled turbine instead of a two-stage high-alloy unit, the Solar Aircraft Company built a single-stage test machine with closed-cycle water cooling of the blades. The water is confined to small passages and its flow directed; each blade is drilled with three holes in the forward part, up which the coolant passes to a chamber in the tip sealed by high-temperature brazing, and from this cavity another three drillings lead the water back to the root. To maintain blade interchangeability fir tree roots are used, and the liquid reaches and leaves the blade through two $\frac{1}{4}$in diameter tubes brazed into the root. The turbine wheel is split transversely and each half welded to one part of the shaft, the two halves being bolted together, as shown in Fig. 4. In the middle of the disc is a housing in which annular spaces connect with the blade supply and return tubes, sealing being by means of an O-ring round each tube. The coolant

passages run through the after shaft, which is atypical in this turbine in that it has a central hole to carry thermo-coupled leads. Outside this hole are others, for incoming and outgoing coolant, which connect with bands of the periphery isolated by seals. The intake apertures are shaped to act as a radial inflow pump and so minimise the supply pressure acting on the seals ; the returning water leaves through numerous drilled holes. The face type seals run at 13,000ft per minute, and dissipate about 4 h.p. each. The coolant is distilled water containing ½ per cent sodium chromate as a corrosion inhibitant ; 100 hours' running at 15,000 r.p.m. and a gas temperature of 1700 deg. Fah. resulted in minor corrosion of the blades, and also in very small leakage, principally from brazed joints. The flow capacity of individual blades fell about 4 per cent, though the associated pressure loss was obscured in running by the pressure drops in the other ducts. The design point of this engine is 20,000 r.p.m. and 1750 deg. Fah. inlet temperature, but the thermo-couple pick-up was not capable of these speeds. The single-stage turbine intake pressure was limited to 26 lb per square inch absolute instead of 68 lb per square inch. The cooling system maintained a temperature at the tip of the trailing edge of around 700 deg. Fah. in a 1500 deg. Fah. gas stream ; the ratio of the differences between gas and blade temperatures and between gas temperature and mean coolant temperature was 0·45 there, rising to nearly 0·6 at the pitch line. To obtain satisfactory cooling of the trailing edge, the upper surface of the blade between throat and trailing edge was curved, and a $\frac{1}{16}$in hole was brought within 0·3in from the 0·060in thick trailing edge.

In this engine the stator blades are welded up from 0·025in sheet steel and air cooled, air from a manifold round the turbine casing passing inward along the leading edge and out again by the trailing edge. The high pressure drop encountered and the leakages discovered called for high-pressure air instead of low, contrary to anticipation, and Solar engineers now favour liquid cooling of the stators. Some corrosion took place due to the inadequacy of the cooling.

The turbine inlet scroll is double-walled, the chromised inner member functioning as a sheath to protect the insulation, and the pressure loads being taken by a mild steel outer wall which runs at 800 deg. Fah. under natural convective cooling.

This very interesting forced convection cooled turbine goes a long way to demonstrate that adequate life and service can be expected from such a unit. Already tests have commenced, on the three-stage turbine engine, to prove a method of blade attachment and sealing which will eliminate the split turbine disc.*

In Great Britain the running of the liquid-cooled experimental high-temperature single-stage turbine at Pametrada is looked forward to. This turbine is intended to establish the technique of turbine construction at temperatures so high that the economic pressure ratios will be high enough almost to halve the engine-room space or even to dispense with the heat exchanger. At present a gas temperature of 2200 deg. Fah. is proposed, the rotor blade surface temperature being 1200 deg. Fah. and the inside of the blade full of liquid metal circulating in natural convection in the intense acceleration field prevailing. The liquid metal is in turn cooled by water circulating through the rotor, the blade root being surrounded by the water. The combustion chamber and turbine annulus of this experimental plant are refractory lined and the stator blades are ceramic ; the illustrations show how the nozzles are arranged and give an impression of their appearance at working temperatures. Since the *raison d'être* of the high temperature machine is economic, residual oil is again the desired fuel and Pametrada is already conducting research into the corrosion and deposition problems it will bring at temperatures around 2000 deg. Fah.

It is in the application to stand-by generation that industrial gas turbines are best established, since simple cycles of relatively high heat rates are acceptable. Of the three gas turbine generators ordered by the Metropolitan Water Board, the 2500kW Metropolitan-Vickers set completed a six-hour full-load acceptance test in the Ashford Common pumping station last July. This set, which was illustrated in this series last year, is a straightforward single-shaft design in which the use of six combustion "cans" around the turbine-compressor coupling allows the path of the gas to lie straight along the set. Volutes and curved ducts to the combustion chamber are thus avoided, as there is no heat exchanger ; distillate fuel is used. The main shaft runs at 7000 r.p.m. and the set gives an efficiency of 17½ per cent at full load. The guaranteed 17 per cent was achieved in works tests as long ago as November, 1952. In these works tests the single-shaft design resulted in a speed rise as low as 5 per cent on suddenly shedding full load. The Brush generator for Ashford Common will be installed in the middle of this year. The English Electric Company is also working on a 2000kW set for the Metropolitan Water Board, and have installed a 2500kW turbine at the Stafford Colliery, Stoke-on-Trent, to run on methane.

Thus, two principal items of interest in 1955, burning of low-grade fuels and cooling of rotor blades, both offer the possibility of a great reduction in the currently forbidding costs of gas turbine installations, the former because of the great price differential between distillate and residual oil, and the latter because of the extreme cost of the high duty alloys at present universal for the highly stressed, high temperature components. The trend, therefore, is clearly towards practical commercial success for the gas turbine.

(To be continued)

* Sumner Alpert, Ralph E. Grey, Delson D. Drake, American Society of Mechanical Engineers. Paper No. 55–A–202.

Coal in 1955

By the late SIR RICHARD A. S. REDMAYNE, K.C.B.

No. I

Great Britain : The Year 1954

THE annual report and statements of accounts of the Coal Board for the year ended December 31, 1954, was not issued until June 20, 1955. The report commences with these ominous words : "In 1954 the demand for fuel and power continued to grow. The coal industry was able to meet only part of the increase and the gap had to be filled mainly by imported coal." What a different record from those incidental to the prenationalisation years !

The output for the year 1954 was as follows : From the mines 214 million tons ; from opencast workings, 10,300,000 tons, or a total of 224·3 million tons, as against 224·2 million tons for 1953. The mines produced nearly 1·3 million tons more than in 1953, but from the opencast workings the output was 1·4 million tons less. The Board states in the introduction to the report that "One major difficulty affecting the Board in nearly all their activities is the shortage of men with suitable training and experience." This was not a difficulty innate to the industry in prenationalisation days—one would have thought that as compared with other industries, with the existing high rate of wages, short working hours and annual holidays, an ample supply of manpower could have been forthcoming. There were 765,400 persons employed in the industry at the end of 1954, or 400 less than at the end of 1953.

The absenteeism of all classes of workers in and at the mines was 12·41 per cent, as compared with 12·21 in 1953. Both figures are very high in view of the fact that 5 per cent is an ample allowance (as has been determined by investigation) for involuntary absence occasioned through illness and accident. The Board's report rightly states, in commenting on attendance : "National averages can, however, only indicate broad trends. The effect of poor attendance is seldom confined to the working places of the absentees ; absence can result in a wider disorganisation of the working of the pit or parts of it. This disorganisation can affect some pits (for example, where there is a shortage of men, a complex layout, or a big reconstruction scheme) much more severely than the figures might suggest."

The financial results for the year 1954 were not very cheering. They showed an overall operating profit of £13·7 million ; but after provision for taxation, interest and interim income payable to the Minister of Fuel and Power, amounting to £17·5, there was a deficiency of £3·8 millions, so that the Board's accumulated deficit at the end of 1954 amounted to £17·4 million pounds. One heavy item in expenditure was incurred by the payment in respect of just over 3,000,000 tons of imported coal. The average price paid was not stated, but the loss over the transaction was, namely, £5,000,000. Now the total coal exported, inclusive of bunkers, but exclusive of patent fuel, amounted to 16,013,000 tons. The question arises, therefore, would not it have been better not to have imported coal, but rather to have reduced exports in order to meet the home requirements, the answer being, of course, dependent on relative prices.

The Board spent £84·7 millions on capital account in 1954 as against £64·3 millions in 1953, having borrowed £54·65 millions from the Minister of Fuel and Power.

Under the heading "The Board's Progress, 1947–54," it was shown that the recovery from the effects of the second world war in respect to production from the mines was not as great as one would have hoped. In 1947 output amounted to 187·2 million tons and in 1954 it had only attained to 214 million tons. On the other hand, costs enormously increased, for in 1947 the cost per ton was 41s. 3d. (against 40s. 3d. per ton in respect of proceeds showing a loss of 1s. per ton) and by 1954 the cost per ton had risen to 61s. 11d. and proceeds to 63s. 6d., showing a profit of 1s. 7d. per ton. Earnings of the workers had also vastly increased, the com-

parison in respect of the years 1947 and 1954 being, per man shift, as follows :—

	1947		1954	
	s.	d.	s.	d.
Face workers	36	10	50	7
All workers	28	10	47	9

The Board wisely decided in the year 1953 to seek advice regarding their organisation "from people with experience in large-scale undertakings," and in consequence an advisory committee was formed which elected as chairman Dr. A. Fleck, the chairman of Imperial Chemical Industries, Ltd. The committee's report was not received until January, 1955, and published in the following month.

Great Britain : The Year 1955

The National Coal Board.—Undoubtedly the most important item in the history of the coal mining industry during the past year was that incidental to the report just mentioned. The advisory committee stated that there was nothing in the legislation which created the Coal Board that prevents the industry being managed in accordance with the best commercial practice. This is so, and undoubtedly "one of the industry's greatest needs is better management at all levels."

One is bound to agree with this, and would point out that this is a factor liable to characterise all nationalised industries. It is erroneous thinking to suppose that public control is a substitute for skilled management and, as the *Sunday Times* aptly phrased it in its comments on the Report on February 20th last, "would automatically assure happy relations with the workpeople. In fact, good management is much more difficult to secure in State industry because of the huge size of the undertakings, the danger of bureaucracy and the lack of the profit and loss incentive." The element of competition and personal responsibility that characterise free enterprise are wanting under a nationalised industry. The Advisory Committee had a most difficult job to do, and one is bound to say that it has done it well. As *The Times*, in its leading article of its issue of February 17th last, stated : "The history of the National Coal Board during its first eight years has been an unhappy one. The high hopes of January, 1947, have not been fulfilled." It regarded the Fleck report as "a fascinating and invaluable document." The recommendation of the committee was that the Board should number twelve, four of whom should be part-time directors, the remainder to comprise the chairman, vice-chairman and six functional directors covering between them the whole of the industry's activities. The Minister of Fuel and Power accepted this recommendation and appointed the new Board, which began its duties on February 21st last, with the recommendation that the whole-time members of the Board should, in future, be drawn from within the industry itself. That recommendation is one which must have the hearty commendation of all those who have had practical experience with the working of such an intricate and complicated undertaking as the production and disposal of coal. One cannot do better in criticising the Board's past history than again quote from *The Times* leading article, where it is stated that "The report stresses that the industry lost virtually a complete level of management" when most of the managing directors of the larger undertakings left it on nationalisation. To-day "the industry's greatest need is better management at all levels . . . at every level of the Board's organisation, and in more departments there is a serious shortage of able people equipped with the right qualifications and experience."

The members of the old Board had placed their resignations in the hands of the Minister of Fuel and Power so that he might be free to make such alterations in the membership as he should think fit in view of the Fleck report, and in consequence the following members were permanently relieved of office, namely, Sir Walter Drummond and Mr. Eric Coates, the two deputy chairmen, and Sir Charles Ellis, F.R.S., the latter having been in charge of scientific research. Sir Walter Drummond is a man of wide practical experience in coal mining and one feels that his going will be a loss to the Board. Of the new appointments there is Mr. James Bowman, at one time a miner in the Northern Coalfield and until his appointment to the Board, of which he becomes deputy chairman, a miner's leader; Dr. William Reid, who was divisional chairman of the Scottish area (son of Sir Charles Reid, at one time a member of the Board) ; Mr. A. H. A. Wynn, mines safety expert from the Ministry of Fuel and Power ; Mr. T. Leatham, the Board's director-general of finance ; and Mr. H. H. Thomas, formerly a senior marketing official of the Board. The old Board may find some consolation in the following appreciative words in the report of the Fleck Committee : "The new organisation for managing 1000 pits previously run by 800 companies was planned and brought into being in a matter of months. Those who performed this task did a remarkable job in the face of difficulties that could have been overwhelming." The new Board became operative as from February 21st last. Sir Charles Ellis was in July last appointed scientific adviser to the Gas Council.

Financial

It is too early at the time of writing to determine with any precision what will be the financial results of the Board's trading during the past year, as we have only the first three quarters' statistical results before us. But for the first quarter the profit derivable from all sources, viz., collieries, opencast working and ancillaries, amounted to £5,899,472. From this had to be deducted in respect of interest £145,000 and loss on imported coal £5,200,000, leaving an estimated profit of only £554,472. But the amount of the estimated interest payable to the Minister of Fuel and Power, amounting to £5,150,000, left an estimated deficit of £4,595,528.

The figures in respect of the second quarter were even worse, for there was an operating loss of £7,874,054 in regard to the collieries, though profits from opencast workings of £425,000 and of £250,000 from ancillaries brought the loss down to £7,199,054. The amount of interest payable at £140,000 and loss on imported coal of £6,700,000 brought the loss for the quarter up to £14,039,054, which with interest payable to the Minister of Fuel and Power left an estimated deficit of £19,189,054 for the quarter. The figures in respect of the third quarter are as follows : the gross profit from all sources amounted to £2,362,452, but as the loss on imported coal was £8,500,000, the sum of £6,537,966 was appropriated from proceeds, leaving a deficit of £1,962,034, and as interest payable was £121,000, there remained the sum of £2,083,034 to be deducted from the quarter's gross profit, leaving it at £279,418. But the interest payable to the Minister of Fuel and Power being £5,250,000, the final result was a loss for the quarter of £4,970,582.

Output

The outputs obtained from the collieries of commercially disposable coal—that from opencast workings not being included—during the last quarter of the year 1954, and the first three quarters of 1955, are given in Table I below.

Table I—*Quarterly Outputs of Coal in Tons*

Quarter	Total of saleable coal	Consumed at mines	Miners' coal	Available for sale
4th quarter, 1954	55,820,509	2,367,789	1,405,388	52,047,353
1st quarter, 1955	54,918,429	2,399,674	1,512,487	51,006,268
2nd quarter, 1955	51,178,926	2,168,812	1,244,138	47,765,926
3rd quarter, 1955	46,474,855	1,917,223	986,049	43,571,583

The statistical information available gives the national output of coal during the year 1955 as 221,570,400 tons, of which 210,207,200 tons came from the deep mines and 11,363,200 tons from opencast workings. The holidays now taken by the miners, restrictive practices at the mines and strikes, have all tended during the past year to militate against production. Sir Hubert Houldsworth, the chairman of the National Coal Board, addressing the Annual Conference of the National Union of Mineworkers at Rothesay on July 5th, last said : "Have you considered, for example, that this year the industry has already lost over 2,000,000 tons of coal in six months by unofficial stoppages and 'go slows'?" Commenting on the situation, *The Times* in a leading article in its issue of September 16th last, said : "It was clear enough, when the large increase in coal prices was announced in early July, that without that increase the Coal Board would be drifting into heavy deficits. It was not so generally expected that the Board would be found to have worked at a loss of over £19,000,000 already in the second quarter of 1955. But so it proves. Moreover, this much larger loss—£13,000,000 more than in the first quarter—was incurred on a considerably smaller production of coal. Disposable output fell from 51,006,000 tons in the first quarter to 47,766,000 tons in the second.

Naturally there are various specific contributory causes of these lamentable results. There were the Yorkshire coal strike, the railway strike, the Easter and Whitsun holidays, and the higher trend of prices of foreign coal, the import of which cost the Board £7,000,000 during the quarter. But the main causes were general—higher wage costs, lagging production, and rising expenses of all kinds. The quarter was the first to bear the impact of the new day wage structure introduced last April and estimated to cost the Board £14,000,000 a year. Wage costs have risen formidably—from 39s. 1·7d. a ton in the first quarter to 41s. 4·6d. in the second. It can only be hoped that the miners will respond positively to the fresh increase in their earnings. They do not seem to have responded to the further new equipment and improvements of conditions and amenities at the pits, which added heavily once again to maintenance and capital charges . . . ."

The manpower in the mines is declining at the rate of about 5000 a year. The output of coal for the year 1954 was only about 70,000 tons more than in 1953. This truth and the small but perceptible decline in output which has recently been in evidence are matters for grave concern.

(To be continued)

Continental Engineering in 1955

No. II—(*Concluded from page 32, January 6th*)

CAR parking facilities in Milan were augmented during 1955 by the completion of two interesting garages, which are illustrated in Figs. 8 and 9. The "Roma" garage is a five-storey building (four above ground and a basement) in reinforced concrete. It will accommodate up to 600 cars, which enter and leave by the ramps shown in the illustration. Parking halls lead from the ramps on each side, at each of the different levels. Cars manœuvre and park under their own power. The garage was built for Fratelli, Meroni and Luige; it was designed by Dott Ing. C. Joriati and Professor C. Ramelli, and built by Impresa Gadola.

The underground garage at the Piazza Diaz has been built for the Milan city authorities, the designer and contractor being Torquato Bertani. It accommodates 450 to 500 cars, but on rather different principles from the "Roma" garage. There are three underground parking floors, with a fourth floor for services below the parking floors. The ramps shown in the illustration lead to the main floor, where there are lifts. The cars are parked in 110 cells, each holding four or five cars. The cars are parked automatically, the lifts moving horizontally as well as vertically. A central area is reserved for servicing and long-period garaging. The garage is of reinforced concrete construction. Originally it was intended to have a fourth parking floor, but the ground conditions were unfavourable, and would have rendered deeper excavation uneconomical.

Another Italian development of 1955 was a fully automatic, self-service car parking installation developed by G. Buttironi and Professor A. Giavarini. A prototype of the invention, called "AU.RO" (Autorimessa Rotante), has been built at Bergamo to hold twenty cars. Here, the cars are stored side by side on two levels. The platforms on which the cars are parked are roller mounted on rails and can be circulated around a framework in a clockwise or anti-clockwise direction, so as to bring any required car or platform to the loading position. In order to transfer platforms from the bottom to the top level or vice versa, a simple parallel motion mechanism is provided at each end of the installation, while on the main horizontal section the platforms are moved by a rack-and-pinion action. When the loading point has been reached, the platform concerned is pulled out mechanically to a position where its car can be driven off or a new one driven on. For sixty cars of 1·9m width, the installation is stated to be about 60m long and to weigh 36½ tons. The maximum time for any car to be loaded or unloaded is said to be about three and a half minutes.

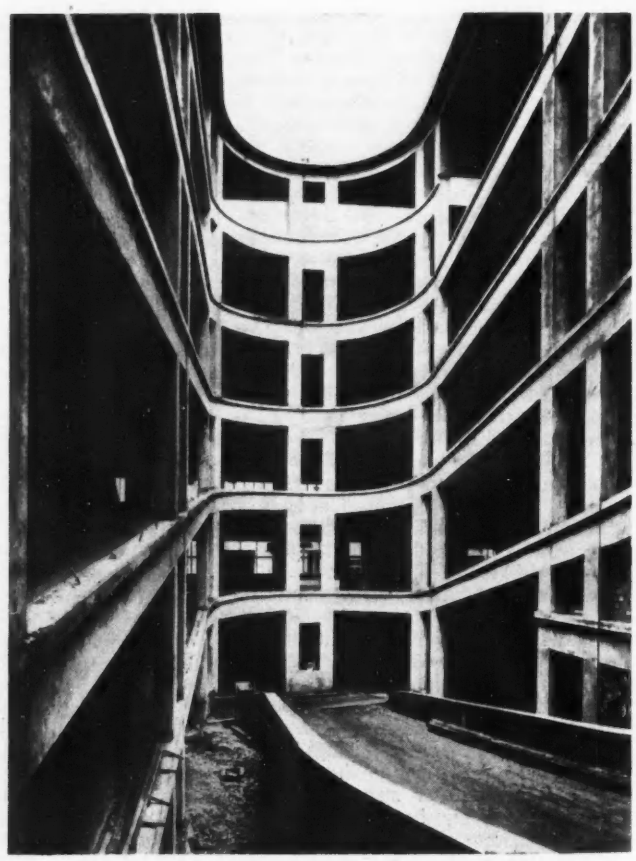
Television Tower at Stuttgart

A novel structure, to carry television transmitting apparatus, was completed during the year at Stuttgart. The more usual solution of a steel lattice tower, braced by ropes at various levels, was not considered of sufficient interest to occupy a prominent site near the city, so the design illustrated in Fig. 10 was evolved. The main structure is a reinforced concrete cylinder, 10·8m in diameter at the base, and 5·1m at the top, with corresponding wall thicknesses of 0·8cm and 0·19cm; its height is 136m. Above the concrete tower are restaurants and sightseeing balconies, and high-speed lifts operate inside the cylinder. A steel lattice tower, 52m high above the balconies carries the television aerials. The total height above ground level is 210m.

Perhaps the chief interest of this structure lies in the design of its foundations. The general layout of the underground works is shown diagrammatically in Fig. 11. The base rests in Lias clay, at a depth of 7·5m, and is 27m in diameter. The entire diameter is not utilised to carry dead loads, however; by concentrating dead load in a bend at the rim of the base, variations in foundation load due to horizontal wind forces are reduced to acceptable limits. Hence, the double cone arrangement in Fig. 11 was adopted, in conjunction with a heavily prestressed base; with the base rim adequately "tied" round its circumference with prestressing cables, this arrangement is clearly advantageous in resisting turning moments due to wind loads, and generally in providing sufficient rigidity and strength. The two "cones" or shells are, of course, in reinforced concrete.

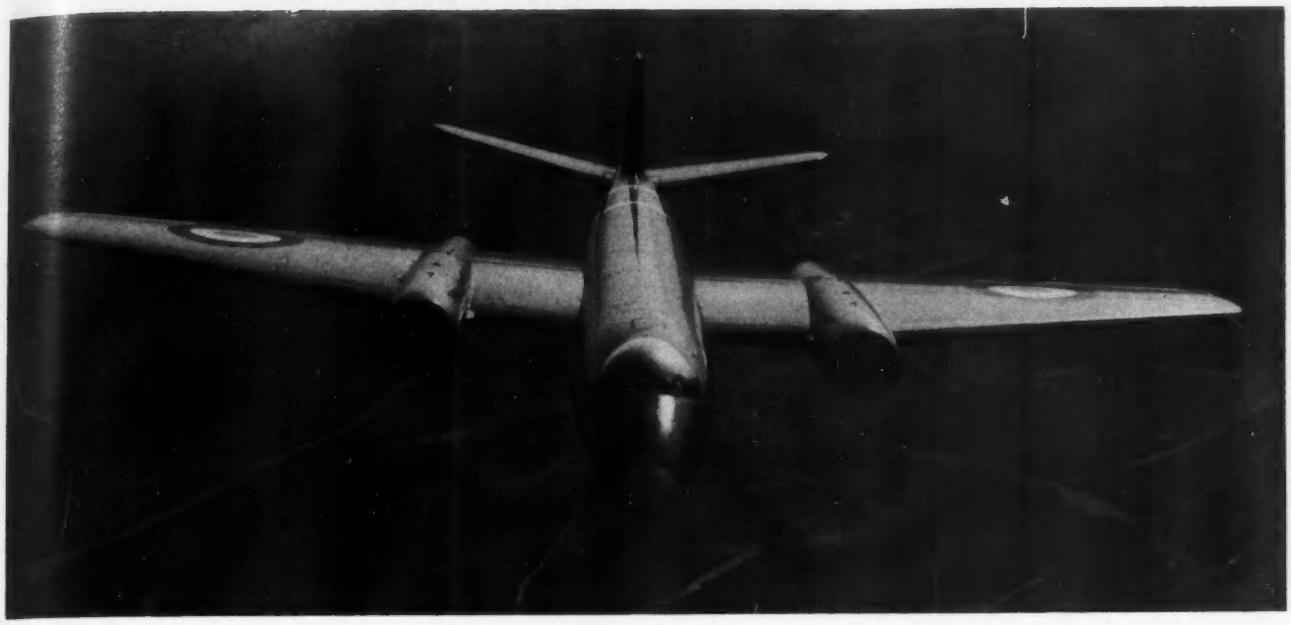
The base rim, whose outside diameter is 27m, is 3·25m in width, and the central ring at the base of the inner cone is 5·5m in diameter. The solid reinforced concrete ring above it, at ground level, is 1m in thickness. The cables cross at four levels (Fig. 12). They are equally spaced at the circumference, and the outer cables of each group are curved, so that they cross over a fairly large area at the centre of the base. There are four sets, each of twenty-eight cables, altogether.

The maximum loading which the Lias clay will withstand is about 3·6 kg per square

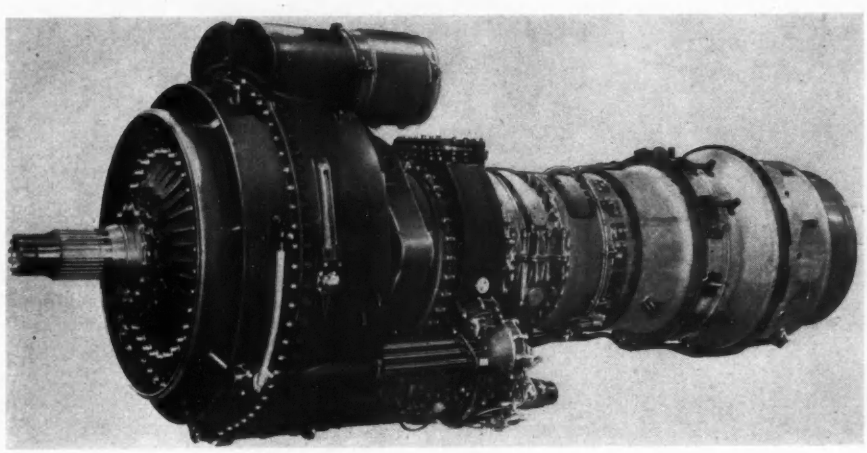


Figs. 8 and 9—Two multi-storey garages were completed in Milan last year. The underground garage at the Piazza Diaz, which will accommodate 450 to 500 cars, is shown on the left. On the right is the access roadway for the Roma garage in the Corso di Porta Roma, which can accommodate 500 to 600 cars

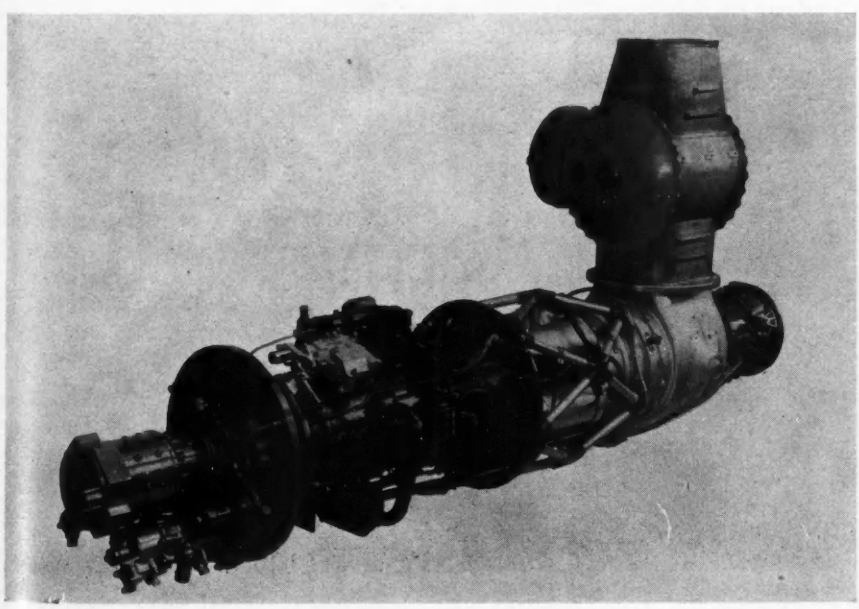
AERONAUTICAL GAS TURBINES



The Bristol gas turbine engines have all incorporated two coaxial turbines in series, and the application of this feature to the pure jet engine has allowed the "Olympus" to regain the grasp of the heavier-than-air altitude record that was previously the preserve of the "Pegasus" poppet-valve piston engine. The "Olympus"-powered "Canberra" shown raised its own record by attaining 65,889ft last year, this being the first time the figure has exceeded 20km. The flight was made by W. F. Gibb, of the Bristol Aeroplane Company

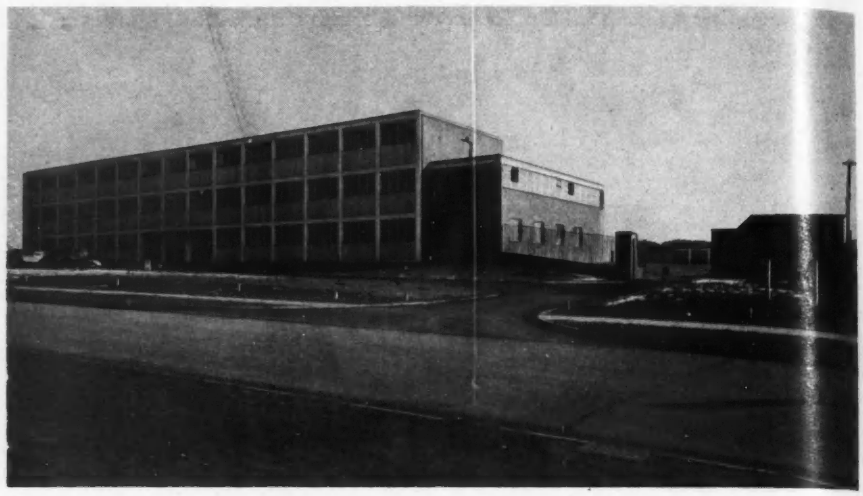


The Rolls-Royce "Tyne" (right) differs from ts well-established predecessor, the "Dart," in that both compressors are axial and the second is driven by a separate turbine. The design features cooled turbine blades and has a pressure ratio of 12 : 1 ; total equivalent power is 4470 h.p. Flight testing is expected to commence this year

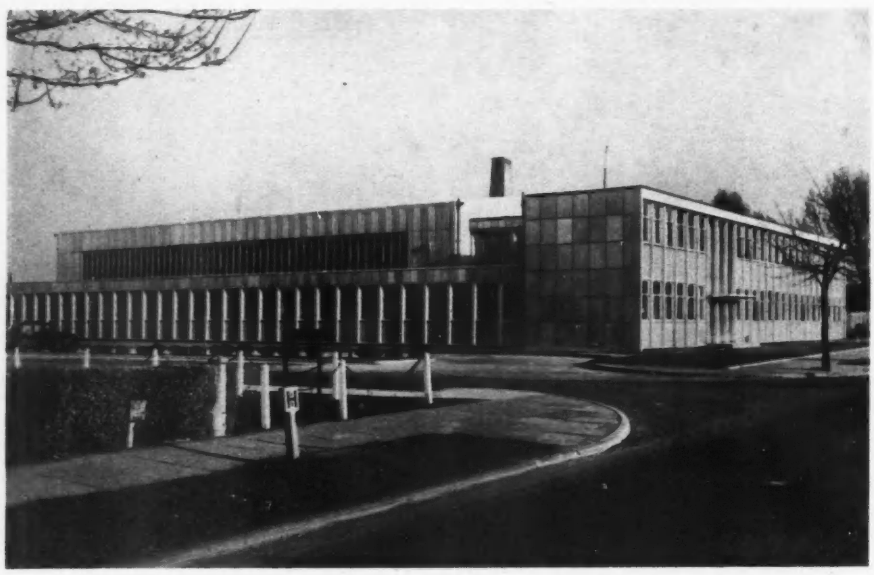


The Napier "Oryx" (left) is a single-shaft gas generator for helicopter propulsion ; an auxiliary compressor delivers air to decrease the temperature and increase the mass of the gas flow to the rotor head. The two-way non-throttling valve seen above the mixing section between turbine and secondary compressor is a part of one of the paired installations in the Hunting Percival "P.74." The gas horsepower of the engine is 750, delivered at 750 deg. Fah. and a pressure of 1·6 atmospheres absolute

RESEARCH AND DEVELOPMENT ESTABLISHMENTS



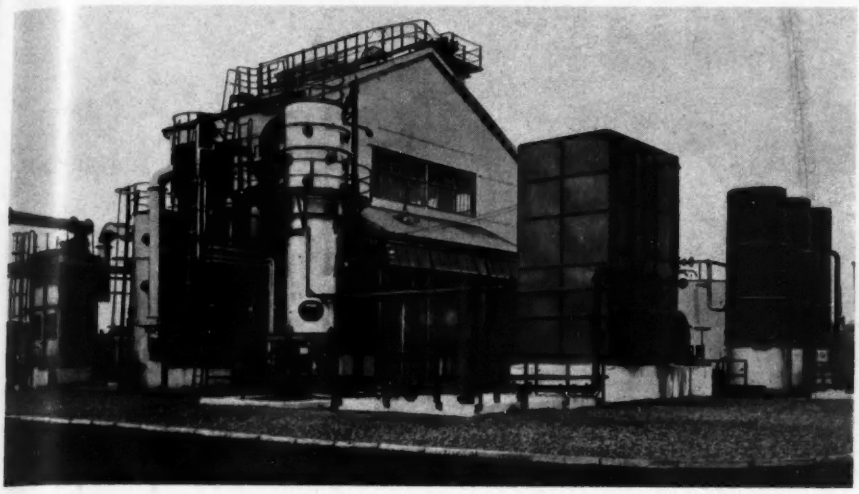
The work of the Department of Scientific and Industrial Research in 1955 is exemplified here by the Water Pollution Research Laboratory's premises at Stevenage, Herts, which were opened last June. The Laboratory had previously carried on its work at various temporary quarters since 1927, when it was formed. Large-scale experimental work can be carried on at the new building, and up to 70,000 gallons per day of sewage can be pumped, if required, from a sewer which crosses the site. Researches into the understanding of the basic processes of sewage purification are to be carried out here, and on other fundamental questions such as those relating to the behaviour of oxygen in streams. Other more immediate researches into such subjects as the treatment of industrial and slaughter-house wastes are also being studied.



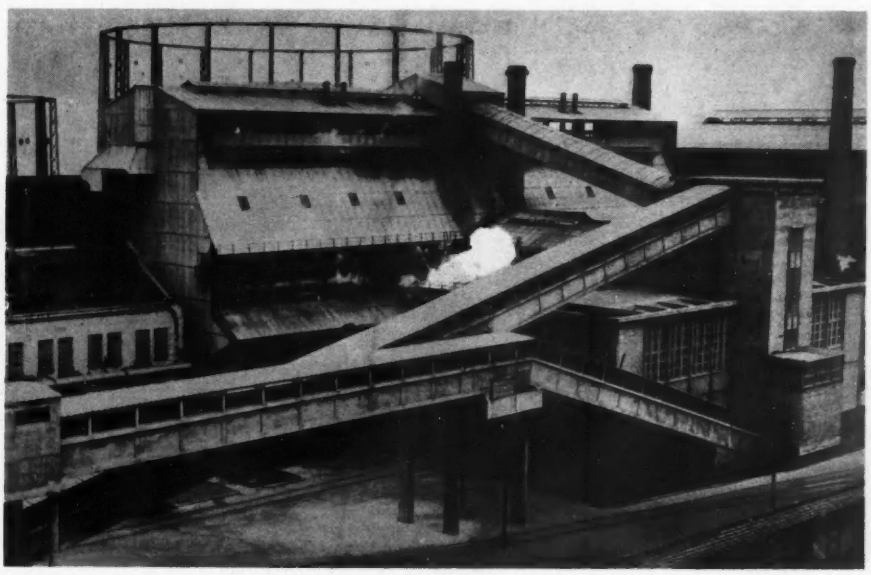
The actual practice of civil engineering construction is becoming increasingly complex, involving special problems of research for contracting firms. One such firm—John Laing and Son, Ltd.—has found it necessary to have its own research and development centre, which was opened last April, at Boreham Wood, Herts. The company's various plant and process sections were combined into a single department in 1953 and it was then decided to build the new centre. The sections themselves had only been formed since the war, because of the increasing importance of new methods and materials and especially of more and better mechanisation. Plant development and the mechanical and electrical engineering problems allied to it are, therefore, stressed at the centre. There are also facilities, including laboratories, for investigations into structural engineering, concrete technology, soil mechanics and architecture, directed, as would be expected, to the particular needs of a large contracting organisation

The rotating beam channel at the Admiralty Hydrodynamic Research Laboratory was built to investigate models moving under water, and the equipment consists of an annular water channel over which spins a power-driven rotating towing beam. The channel, which has a maximum diameter of 136ft, a width of 34ft, a depth of 15ft and contains over 1,000,000 gallons of specially treated water, is of reinforced concrete construction and has greenheart and elm vertical baffles, placed around both walls, alternating with radial precast reinforced concrete baffles across the floor of the tank. Concrete sloping beaches projecting from the walls reduce surface disturbances. Two symmetrical arms attached to a central hub form the rotating beam, which has a span of 122ft and weighs 60 tons and is driven at 30 r.p.m. through bevel and spur gears by a 1510 h.p. electrical motor. This speed of rotation gives a model attached at 50ft radius a speed of 90 knots or a speed of 100 knots at 55ft radius

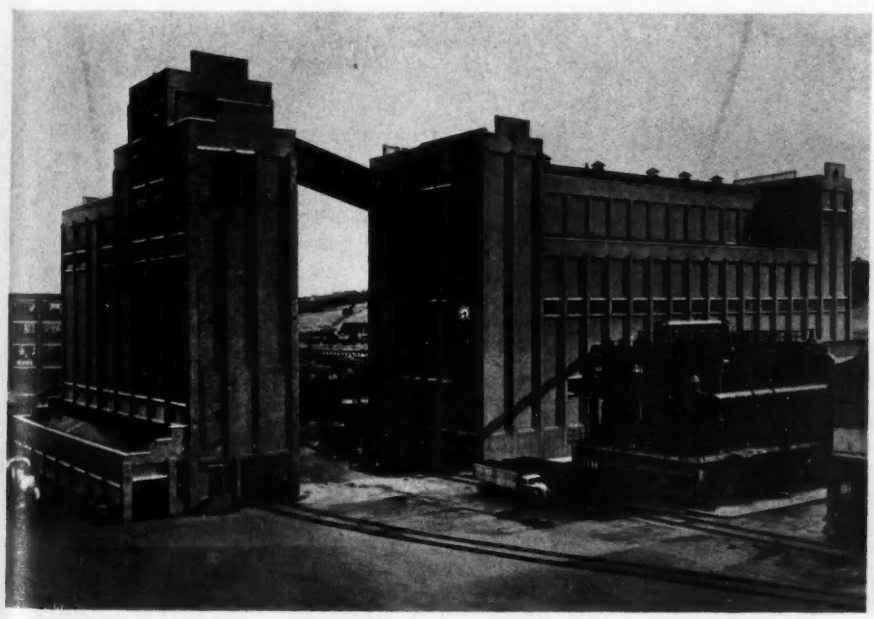
GASWORKS EXTENSIONS IN 1955



During the past few years the nationalised gas industry has paid particular attention to the gasification of oil in its investigations into the production of gas from sources other than coal. One such oil gasification plant is that of the West Midlands Gas Board at Stafford, which is illustrated on the left. It uses the "Onia-Gegi" process and produces 1,000,000 cubic feet of gas a day. At present five oil gasification plants, using the "Onia-Gegi" or the "Segas" processes, which are in operation in this country, produce a total of 5,000,000 cubic feet of gas a day, and sixteen more plants are on order



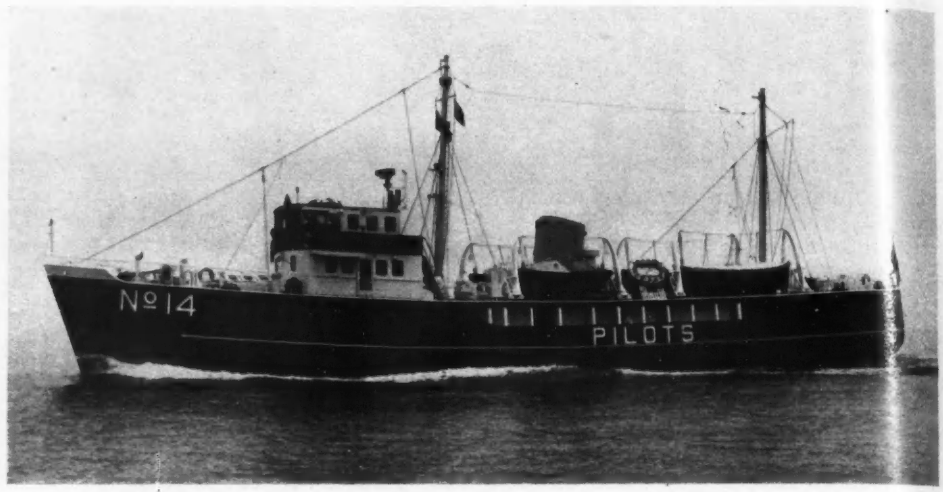
Extensions to the Willoughby Lane Gasworks of the Eastern Gas Board have involved the construction of a new continuous vertical retort house capable of producing 8,000,000 cubic feet of gas a day, and a producer gas dilution plant with a capacity of 2,000,000 cubic feet of gas a day. The illustration on the right shows the new retort installation and power house and part of the elaborate conveyor plant housed in prestressed concrete structures installed for coal and coke handling. The main contractor for this carbonisation plant was the Woodall-Duckham Construction Company, Ltd., and it includes sixty-four 82in continuous vertical retorts arranged in four benches, each of four sections of four retorts

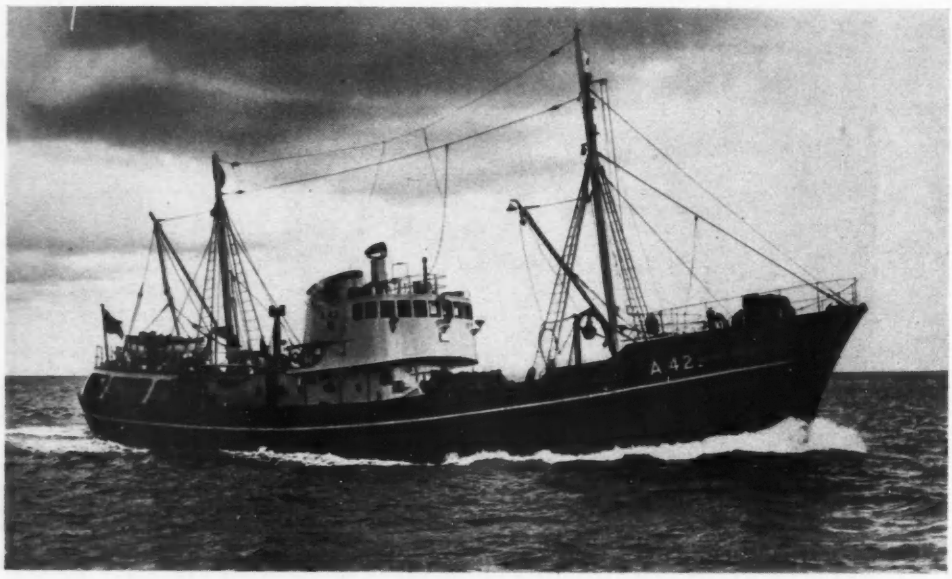


A new installation with a nominal daily capacity of 8,000,000 cubic feet of gas completed at the Etruria gasworks, Stoke-on-Trent, forms a completely self-contained extension adjoining the main works. The new carbonisation plant, supplied by West's Gas Improvement Company, Ltd., consists of ninety-six 50in continuous vertical retorts in four separate benches, each of three settings and each setting containing eight retorts in heating units of four. The photograph we reproduce shows the clean design typical of modern retort houses, with the complementary coke storage and grading building at the rear

SOME SMALL VESSELS OF 1955

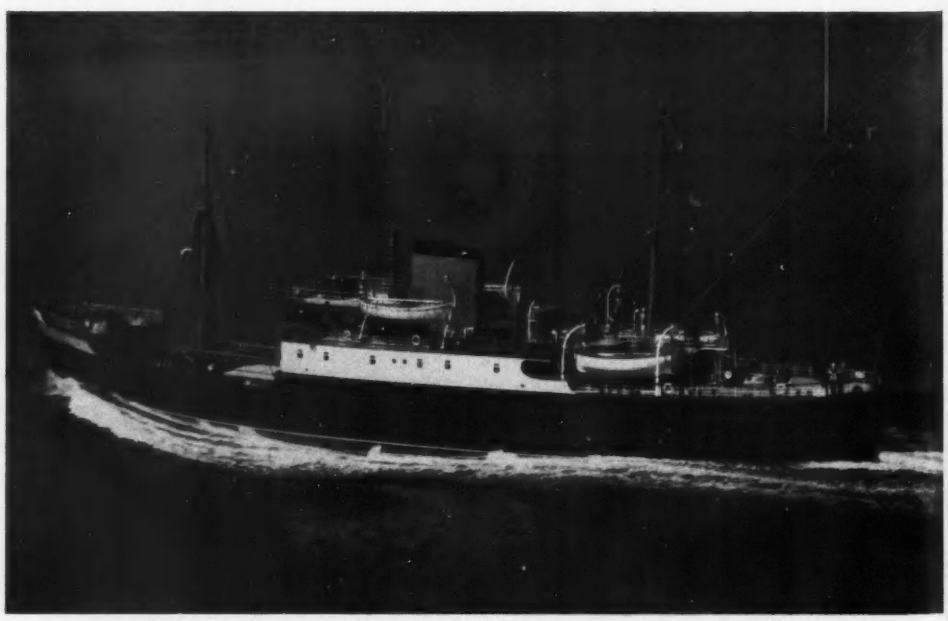
The twin-screw pilot vessel "Pathfinder" was built by Philip and Son, Ltd., for the Pilotage Department of Trinity House, is based on Dover, and has accommodation for twenty-two pilots. The ship has a length overall of 175ft, a length between perpendiculars of 157ft, a breadth moulded of 30ft, a depth moulded of 14ft, and a mean draught of 10ft 3in. Electric deck machinery and a hydraulic steering gear is installed, and demands for electrical power are met by two 60kW generators driven by 100 h.p. diesel engines, while the ship is propelled at 11½ knots by two British Polar Mark M.46 I two-cycle, single-acting diesel engines, each developing 500 b.h.p. at 325 r.p.m.



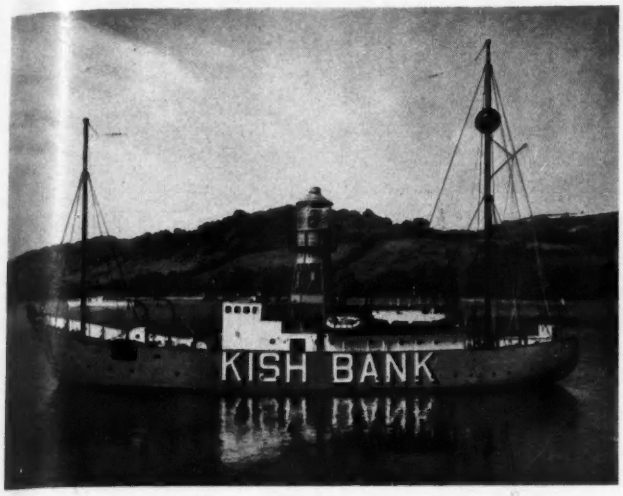


The motor trawler "Mount Everest," which has a length between perpendiculars of 120ft, a breadth moulded of 25ft and a depth moulded of 12ft 6in, was built by John Lewis and Sons, Ltd., for the Seafield Fishing Company, Ltd., of Aberdeen. Propulsion is by a Mirrlees Mark K.D.S.M.6 diesel engine, fresh water cooled with intercooler in the turbo-charger system, arranged for direct drive and direct reversing, and developing 690 b.h.p. The fishroom has a capacity of 7000 cubic feet and the electric trawl winch has winch barrels capable of taking 1200 fathoms of 2¾in warp. A Mirrlees Mark T.LA.6 diesel engine, direct coupled to a generator, provides power for the trawl winch and two auxiliary diesel sets drive air compressor bilge pump and 15kW generators, while a vertical Cochran boiler supplies steam for heating

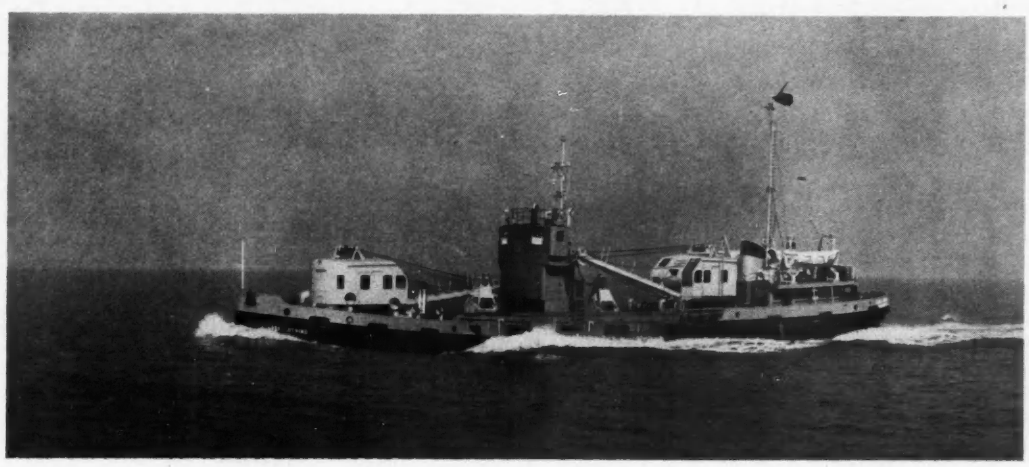
The Caledon Shipbuilding and Engineering Company, Ltd., built the Lighthouse Tender "Pharos," to the order of the Commissioners of Northern Lighthouses. Accommodation is provided for the Commissioners and also for lighthouse keepers, and the principal dimensions of the ship are: length overall, 257ft; length between perpendiculars, 235ft; breadth moulded, 40ft; depth moulded, 19ft 6in, and service draught of 13ft. Stowage for large buoys is arranged in the forward hold and for handling purposes there are one 6-ton and two 3-ton derricks, and a 15-ton heavy derrick operated by electric winches of special design, while four electric capstans are also installed. Electric power is supplied by three 90kW diesel-driven generators and a speed of 14 knots is maintained by two seven-cylinder, two-stroke, single-acting British Polar diesel engines, each developing 985 b.h.p. at 220 r.p.m.



SPECIAL PURPOSE SHIPS OF 1955



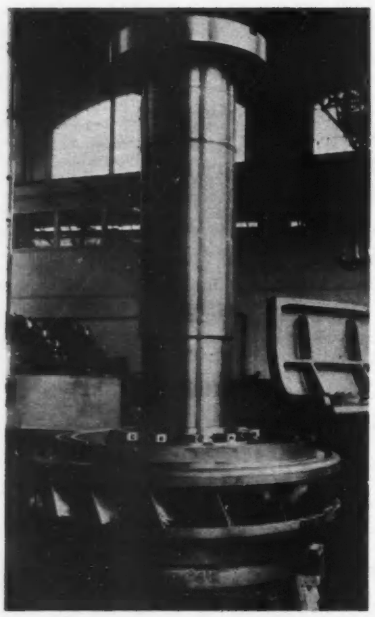
The light vessel "Shearwater," which is stationed on the Kish Bank off the entrance to Dublin Bay, was built by Philip and Son, Ltd., for the Commissioners of Irish Lights. Exceptionally large bilge keels are fitted to minimise rolling, and the vessel, which is specially strengthened to withstand the severe gales round the Irish coast, has a length overall of 136ft 5in, a beam of 25ft and a moulded depth of 15ft. Mooring is effected by a 4-ton anchor attached to 1⅛in Tayco stud link cable, and there are two 30-cwt emergency anchors. Anchors and cables are handled by a windlass operated by a rotary air engine. In the machinery space there are four lighting sets, each consisting of a 4½kW generator driven by a 7½ b.h.p. oil engine, and two fog signal sets, each consisting of an air compressor driven by a 34 b.h.p. oil engine, which supply air via three air receivers to a "G" pattern fog signal diaphone. The light is 40ft above sea level in a tower and is visible for 10 miles. The crew are accommodated in single and double-berth cabins



The dredger "Lake Lothing" was built for the British Transport Commission by Henry Robb, Ltd. Two 5·5-ton diesel-driven grab dredging cranes are mounted and the craft has the following particulars: length between perpendiculars 156ft, breadth moulded 34ft, depth moulded 14ft, mean draught 12ft 3in, deadweight 860 tons and hopper capacity 828 cubic yards. An eight-cylinder four-stroke oil engine of 600 b.h.p. drives a propeller at 167 r.p.m. through reduction gearing to give the dredger a speed of 9 knots

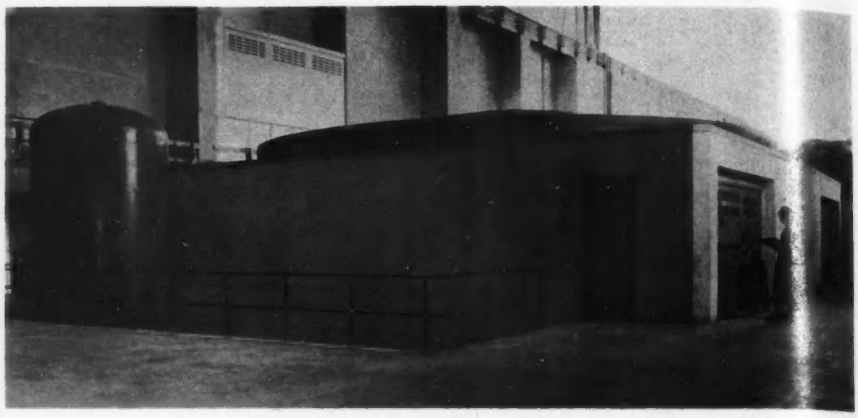
The self-propelled floating crane "Atlas," built by Lobnitz and Co., Ltd., for the Mersey Docks and Harbour Board, is of double skin construction, and has a length between perpendiculars of 165ft, a breadth moulded of 55ft 6in, a depth moulded of 13ft, and a draught loaded of 8ft 8in. Steering is by twin double balanced rudders. A trial speed of 10·2 knots was attained when driven by twin screws, each powered by a triple-expansion steam engine developing 375 i.h.p. at 97 r.p.m., and there are two 250kW steam-driven generators and one diesel-driven generator which supply power to the forward winch and to the crane. This was built by Cowans, Sheldon and Co., Ltd., weighs 480 tons, and has a main hook capable of lifting 100 tons at 15ft per minute, the maximum radius being 40ft, and a 60ft per minute 5-ton auxiliary hook. Blocks and derricking screws are driven by electric motors. A specially strengthened area of deck is provided amidships to take 160 tons of cargo, the space being arranged to accommodate a railway carriage on each side

CONTINENTAL HYDRO-ELECTRIC SCHEMES

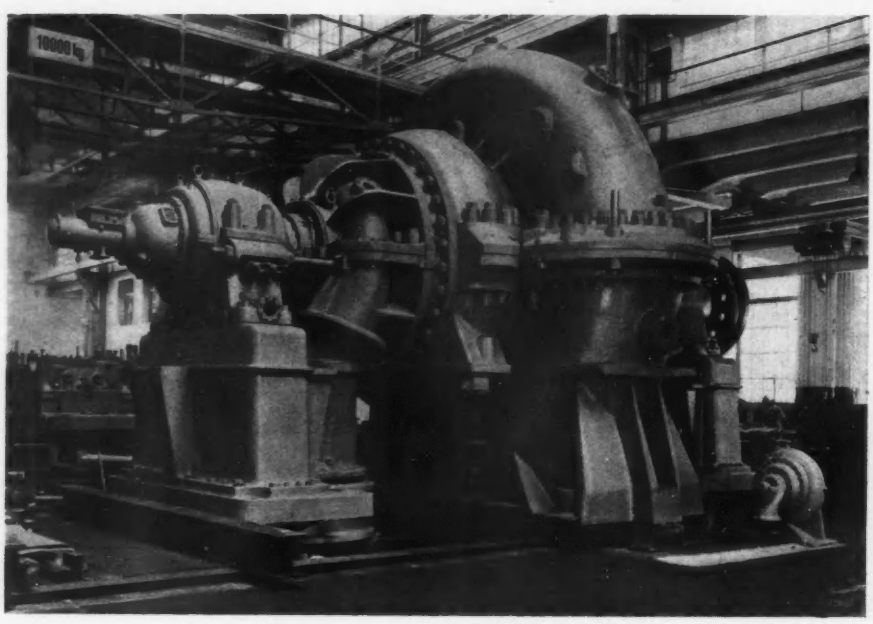


The Francis turbines of the Fionnay power station, Valais, Switzerland, operate under unusually severe conditions. The shaft and cast stainless steel runner of a turbine are illustrated above. The maximum gross head on these machines is 472·5m (1509ft), and the minimum gross head 307·5m, giving a rated output from 42·5MW to 27·5MW. The maximum flow is 11·5 cumecs, they operate at 750 r.p.m., with a specific speed of 20·2 (in British units) and a runaway speed of 1400 r.p.m. Manufacturer: Escher Wyss A.G.

Another recent Swiss hydro-electric development is the low-head station of Birsfelden, on the River Rhine. Installation of an alternator at Birsfelden is shown on the right. The head here is low and the flow large (7m and 325 cumecs for each of the four machines). Each alternator (26–28·6MVA) operates at 68 r.p.m. and has an external diameter of 46ft (stator diameter 11·5m); they are of "umbrella" design and have an independent excitation system. Manufacturer: Oerlikon Engineering Company (the two machines illustrated) and Siemens-Schuckert



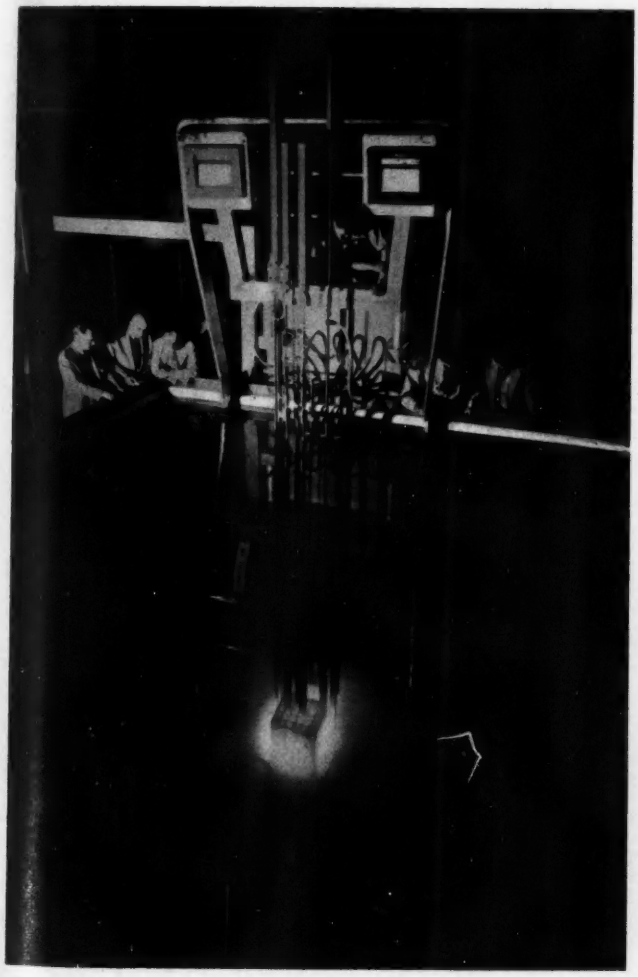
The alternator room of Jochenstein power station, part of which is shown here, illustrates the clean design of modern hydro-electric plant. This scheme is a low-head one on the Danube in Austria, which was opened last year. There will be five 28MW sets in the complete station, generating 940 million kWh annually, and the head is 9·6m. Three turbines were supplied by J. M. Voith G.m.b.H., and two by Escher Wyss A.G. The alternators were built by A.E.G., Siemens-Schuckert, and Elin. The last two sets will be installed this year



The Glockner-Kaprun hydro-electric scheme in Austria is a vast long-term Alpine project, owned by the Tauernkraftwerke A.G., of Zell am See. There are two main stages in the scheme, each with a reservoir, and associated tunnels and a power station, as well as various other works. The upper stage reservoir—Mooserboden—discharges into the lower—Wasserfallboden—through a power station at Limberg dam. During off-peak periods, water can be pumped back to the upper reservoir, and one of the pumps for Limberg power station is illustrated here. There are two 56MW sets installed, each comprising a Pelton turbine, an alternator, and a pump. The head on the pump is 320m to 410m, the discharge varying from 16·6 to 11·7 cumecs; the pumps are two-stage machines operating at 500 r.p.m. The complete scheme will generate 800 million kWh annually (including 200 million kWh consumed by pumping) from a capacity of 317MW. Pump manufacturer: Escher Wyss A.G.

ATOMIC ENERGY IN THE UNITED STATES IN 1955

The "Swimming Pool" research reactor, illustrated below left, was shown by the United States at the Geneva Conference last summer and was the first American operating pile to be exhibited outside the United States. Two research reactors of this design are at present under construction at Pennsylvania State University and the University of Michigan. After the Geneva Conference this particular reactor was sold to the Government of Switzerland. The reactor operated in a cylinder of purified water, 10ft in diameter and 21ft deep. The core of the reactor—the fuel elements containing 18 kg of uranium, enriched to 20 per cent in uranium 235—was situated near the bottom of the tank, on a pedestal. The water acted as a shield to retain radiation and as the moderator. The upper illustration shows the launching of the U.S.S. "Seawolf," the second American nuclear-powered submarine, at the yard of the Electric Boat Division, General Dynamics Corporation, Groton, Connecticut, on July 21, 1955. The vessel will be propelled by the submarine intermediate reactor (SIR) Mark B, which is based on the SIR Mark A. This land-based prototype has now undergone full-power tests at the West Milton test facility of the General Electric Company. Surplus steam from the SIR Mark A has been channelled into a 10MW turbo-generator installed and operated by the General Electric Company and the resulting electrical output is being sold by the A.E.C. in the first commercial usage of atomic-powered electricity in the United States. In the field of industrial radiography and non-destructive testing of materials the 1,000,000V and 2,000,000V Van de Graaff X-ray generators developed by the High Voltage Engineering Corporation have found growing application. The new lift truck mounting, illustrated below right, has greatly contributed to the portability of the unit. The two sizes of generator can effectively penetrate up to 5in and 10in of steel, respectively. They have a weight of only 2500 lb and 4500 lb, respectively



BRIDGE CONSTRUCTION IN THE UNITED STATES

The recently completed 1825ft long Paseo Bridge across the Missouri River at Kansas City, Missouri, is said to be the longest self-anchored suspension bridge in existence. The four-lane bridge has two 26ft roadways and comprises a 616ft main span and two side spans each of 308ft. The approach spans are continuous deck plate girders, measuring 174ft and 90ft at the south end of the bridge, and 219ft and 110ft at the north end. The clearance above high water at the centre is 55ft and the supporting towers are 136ft high. The diameter of the wrapped cables is 12in. The bridge superstructure was fabricated and erected by the American Bridge Division of the United States Steel Corporation

Much progress was made during 1955 in the construction of the 2·8 mile long Tappan Zee Bridge (right) crossing the Hudson River between Tarrytown and South Nyack, New York. The structure, which will carry the New York State "Thruway" across an extremely wide reach of the river, comprises a main channel cantilever bridge 1212ft long with two 602ft long anchor spans. The approach spans of the six-lane bridge are supported on cofferdam piers spaced 235ft to 250ft apart. An interesting aspect of the main pier construction was the use of buoyant concrete boxes, with piles up to 295ft long, driven through these boxes at the bridge site. The bridge superstructure is being fabricated and erected by the American Bridge Division of the United States Steel Corporation

Newark Bay Bridge, below, will connect the New Jersey Turnpike at Newark Airport with the Holland Tunnel leading to Manhattan. Closure of the tied arch steelwork was effected on August 10, 1955. The arch span, which is composed of continuous steel trusses, has an overall length of 1270ft and is supported on four twin-shaft piers. The arch span comprises a 670ft centre span and two continuous side spans, each of 300ft. The centre span provides a vertical clearance of 135ft above water, which will admit large vessels into the upper section of Newark Bay. The six-lane bridge, with its approaches, will be 9560ft long, with two 36ft roadways separated by a 4ft centre mall. The bridge superstructure was fabricated and erected by the Bethlehem Steel Company

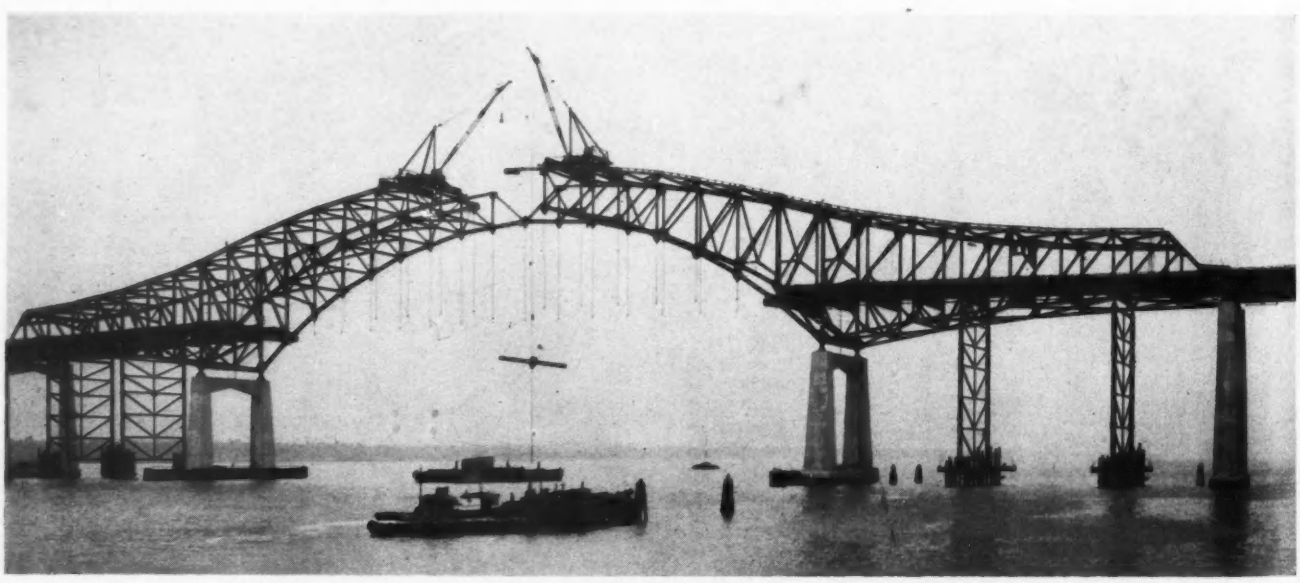


Fig. 10—The television tower at Stuttgart has sightseeing balconies and restaurants about 145m above ground level, with an aerial array on a steel lattice tower above them. The total height of the tower is 210m

centimetre, but this figure is not reached in the tower base. The tower weighs about 3000 tonnes, and the foundations an additional 1500 tonnes; the weight of spoil removed down to 7·5m depth was about 3000 tonnes. Wind loading was based on a wind speed of 47m per second (force 11–12), giving a total load of 172 tonnes, corresponding with deflections of 30/35cm at the sightseeing platform, and about 150cm at the very top. The natural period of vibration of the tower is six seconds. An ultimate settlement of 3cm was computed for the foundation design, and the concrete cylinder will shrink 6cm in the first three years of its life, it is thought. This is one of the factors

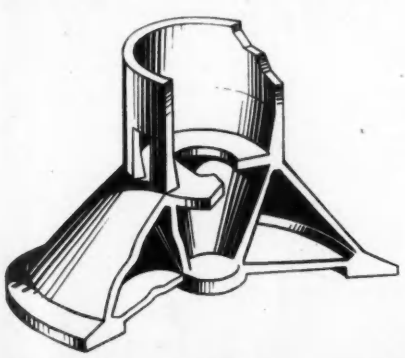


Fig. 11—Diagram of foundation arrangement for television tower

taken into account in designing the equipment, such as water pipes, in the tower structure.

The structural design of the television tower at Stuttgart was in the hands of Dr. Ing. Fritz Leonhardt. It may be recalled that last June, Dr. Leonhardt gave a lecture at the Institution of Civil Engineers entitled "Prestressed Concrete with Concentrated Tendons," in which the system of prestressing which he has developed was explained. The system has been used, particularly, for a number of highway bridges in Germany, which offer considerable interest in their design and construction.

Rhine Bridge at Mainz

Another German structure is the Kaiserbrücke two-track railway bridge over the Rhine near Mainz. This crossing consists of two Warren girder sections, one 313·2m long, bridging the river from the left bank to an island in three continuous spans (Fig. 13). The other has two continuous spans totalling 237·2m from the island to the right bank. The part across the island is formed by two continuous plate girder sections, each of three spans, together 240m long. With trusses at 9·2m centres and a truss height of 10m, the left-bank portion weighs 2373 tons, and the right-hand portion, with trusses 11m high, 2002 tons. Total steel weight is 5376 tons. These figures were made possible by the use of welded box section members of St.52, an aluminium deoxidised steel of 40kg per square millimetre yield point, 56kg per square millimetre ultimate load, and 33 per cent elongation, for which working stresses of 21 kg to 24 kg per square millimetre are permissible. In order not to obstruct shipping, left bank truss sections up to 150 tons were prefabricated and floated into position by crane. Main truss assembly on the site was by riveting, while subsidiary assembly was carried out by welding *in situ*. Overall design was in the hands of the Mainz railway authorities, while the actual construction was carried out by M.A.N. (Werk Gustavsburg), Dortmund Union Brückenbau, and Michael Lavis, Offenbach.

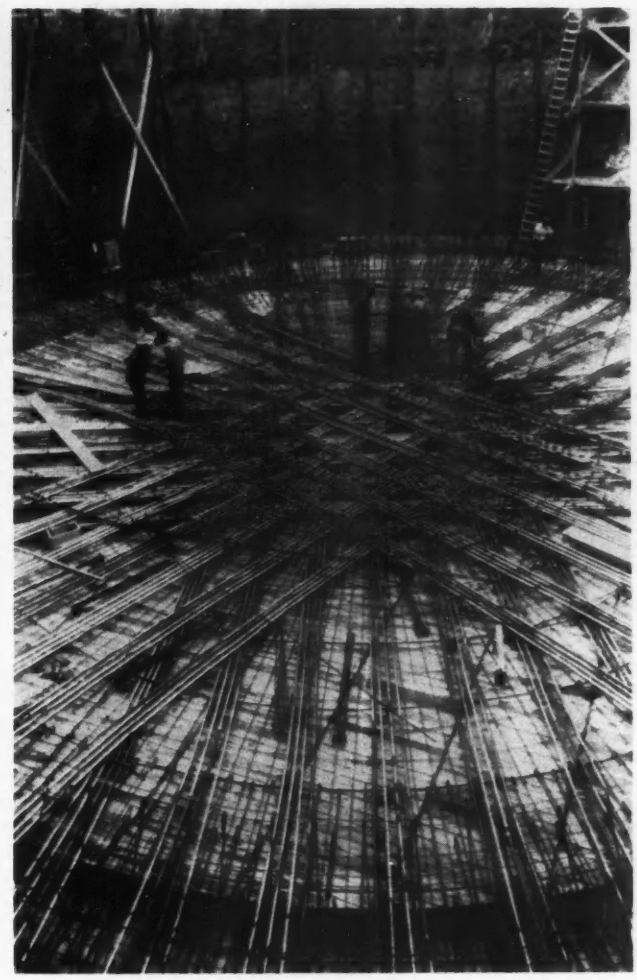


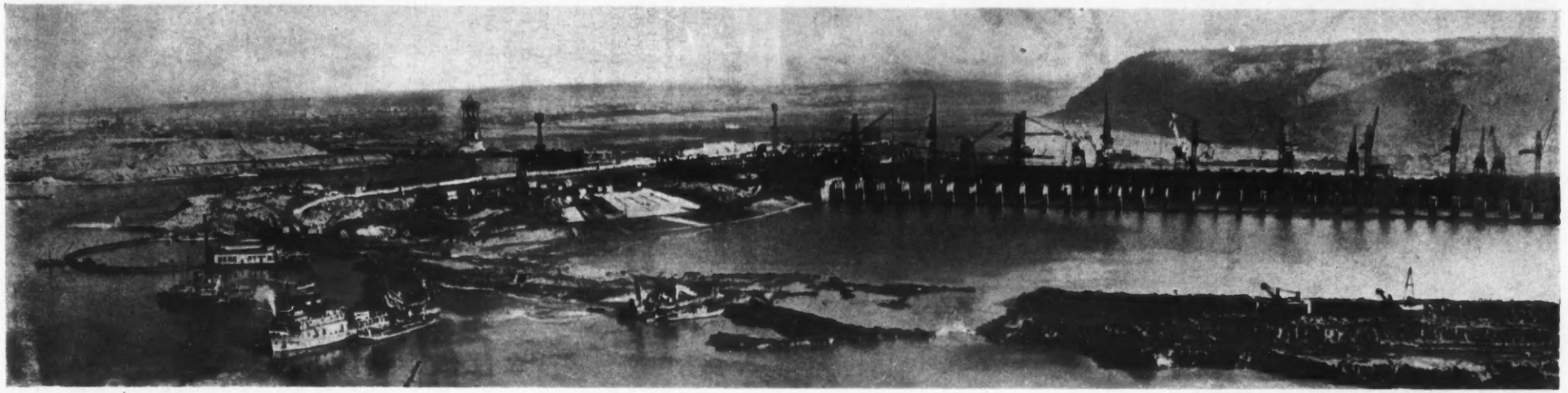
Fig. 12—Prestressing cables in position in the base of the foundation of the television tower, 7·5m below ground level

Hydro-Electric Progress

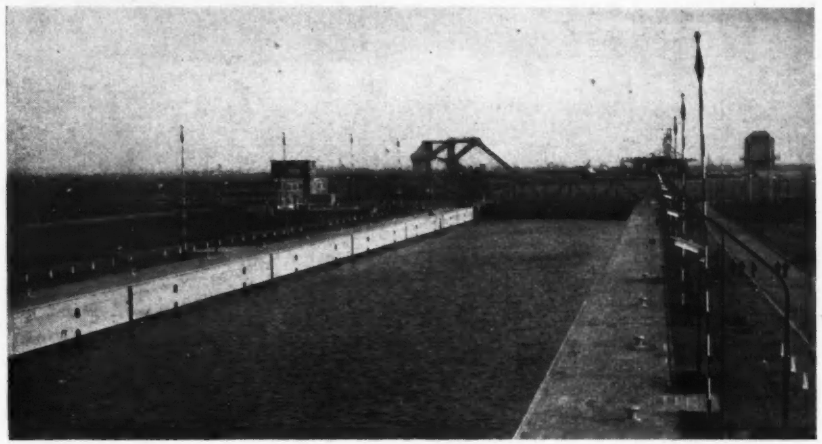
At the beginning of this review, we commented upon the importance attached to developing sources of energy, and of the difficulties which have been experienced, on the Continent as well as in this country, in increasing the production of coal. This situation brings encouragement to the development of hydro-electricity, and once again the year was one of great activity in those European countries which have appreciable natural resources of hydro-electric power. Some of the largest civil engineering projects were based on hydro-electric power generation, and we illustrate on page 66 two such projects, the Grande Dixence dam, in Switzerland, and the Kuibyshev development on the Volga, in Russia. The two Russian schemes at Kuibyshev and

Fig. 13—The rebuilt Kaiser bridge over the Rhine at Mainz. The illustration shows the three-span section from the left bank to an island

LARGE CONTINENTAL CIVIL ENGINEERING SCHEMES



The potential hydro-electric value of the Volga River in the U.S.S.R. has been estimated at nearly 12,000MW, most of which can be exploited. Recent progress in the construction of the Kuibyshev scheme on that river is illustrated above. The Kuibyshev station will have an ultimate installed capacity of 2100MW and will generate about 10,000 million kWh annually. Our illustration shows the power station under construction. The cofferdam, which was constructed to dewater the power station substructure, is evidently being excavated by the dredgers and excavators, but the works at a higher level are still in progress. The scheme involves 4km of earth dam construction, part of which is shown on the left. Aggregates for the power station are brought by cableways and the tall river towers of the cableways can be discerned. It appears that a cofferdam has been built across the river, but no impounding has been started. The normal head of the scheme will be 22·5m, and there will be twenty turbo-alternator sets installed when the work is completed



The Baudouin lock in Belgium (lower left) forms a new entrance to the port of Antwerp. The lock is the largest in Europe, except for the Ijmuiden locks in Holland. It has a length, between outer gates, of 360m, a width of 45m, and a depth at high tide of 15·5m. The lock was inaugurated last November

Grande Dixence dam in Switzerland (right) will ultimately be 932ft in height. It is a gravity dam, which is being built in stages. The second and third stages will comprise a number of blocks, separated from the earlier work by open slots, which will be filled to render the structure monolithic, when the reservoir is empty. The position and shape of the slots was specially studied and tested photo-elastically, and the serrated shape of one of the slot surfaces, forming the "toe" of the first stage, is shown. The illustration also gives a good idea of the size of the job and of the constructional details. An output of 1670 million kWh annually (90 per cent in winter), and an installed capacity of 720MW, are the principal figures for the completed Grande Dixence scheme

Stalingrad will have substantially higher outputs of electrical power than any other European hydro-electric schemes, according to the figures which are given for them. The start of constructional work in an even larger scheme was announced by the Russians during the year. This scheme is, however, in Asiatic Russia, at the Bratsk rapids on the River Angara, in Siberia. It is stated that, according to preliminary estimates, it will generate more power than the Kuibyshev and Stalingrad stations combined (i.e. about 20,000 million kWh annually). We have no detailed information about this scheme, but apparently preliminary works—roads, camps, and so on—were started during 1955.

Development of the River Rhône in France, continued during the year, with appreciable progress on the Montelimar project. The Donzere-Mondragen scheme, on the Lower Rhône, which was completed some years ago, will doubtless be recalled. The next stretch of river, immediately above it, is now being developed by the Compagnie Nationale du Rhône, in a scheme similar in general layout to the earlier one. It involves a barrage across the Rhône, a head-race canal 12km in length, a power station combined with navigation lock and spillway, at Chateauneuf-du-Rhône (6 × 50MW Kaplan turbo-alternator sets), and a tail-race canal 2km long. Work was in progress during the year on the substructure works, such as draft tubes, of the power station and the piers of the main barrage were substantially completed. The barrage has six 26m spans, each closed by a pair of lowering crest gates, a form of sluice gate which is now being widely used on Continental works of this kind. The scheme is due for completion in 1957.

Fig. 14—Runner of Francis turbine for a net head of 1410ft

Recent developments in generating plant for hydro-electric schemes are well illustrated by Plate 14. Two recent low head schemes, in which turbo-alternators of very large size have been built for comparatively modest outputs of power are illustrated, namely, the Birsfelden scheme on the Rhine in Switzerland, and Jochenstein power station on the Danube in Austria. Birsfelden has already been described in these columns (THE ENGINEER, June 4 and 11, 1954).

Turning now to high head schemes, Plate 14 shows the runner of a Francis turbine for the Fionnay (Mauvoisin) scheme in Switzerland, which will operate under a very high head for a turbine of this kind. A recent trend for Francis turbines has been to extend the range for which they are used towards higher operating heads. In fact, in an increasing number of cases, Francis turbines are provided where the operating head falls within a field which, not so many years ago, was generally strictly reserved for the impulse or Pelton turbine. The reason for this trend is mainly one of economy. Francis machines run at much higher speeds than the corresponding impulse machines designed for the same heads and outputs and the result is that the dimensions and costs not only of the equipment but also of the building required to house it are appreciably lower. This development has been made possible owing to the progress achieved both in hydraulics and in the manufacture and casting of special steels.

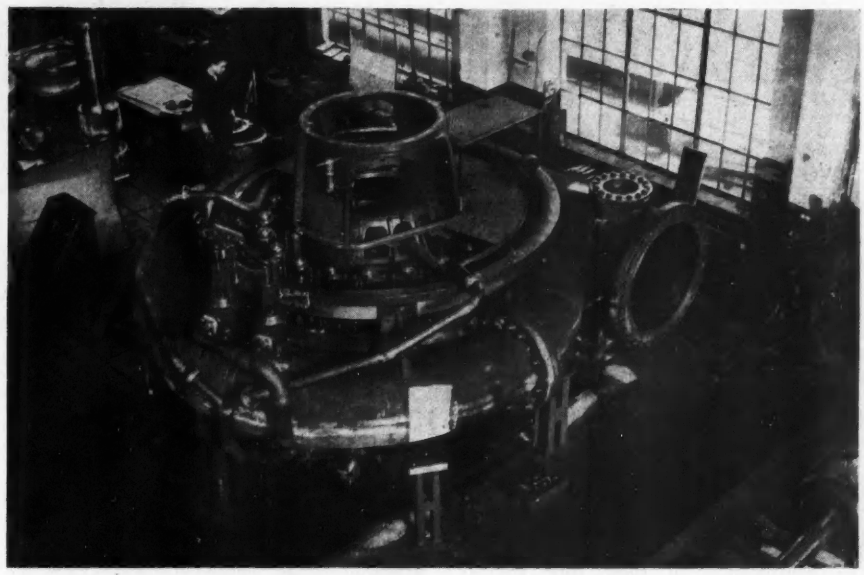


Fig. 15—High-head Francis turbine for Paradela Vila Nova power station, Portugal, assembled at maker's works

A further example of a high head Francis machine is illustrated in Figs. 14 and 15. This turbine was installed last year at the Vila Nova (Paradela) power station in Portugal. It was designed and built by Ateliers de Charmilles S.A., Geneva, and is a vertical shaft machine of 76,000 h.p., operating at 600 r.p.m. with a maximum net effective head of 1410ft. The runner is an integral casting of 13 per cent chrome stainless steel. All the main parts of the turbine which withstand hydrostatic pressure, such as the spiral casing, cover plates, wicket gates, &c., are made of high-grade cast steel. It may be recalled that Vila Nova power station, which is on the River Cavado, was described in THE ENGINEER of November 20, 1953. A group of British companies had installed plant at Vila Nova, and other Portuguese hydro-electric developments, and their work was described in a series of articles at that time. It was noted that Vila Nova power station was to utilise two tributary streams and an installation of 96MVA was then in operation, supplied from a reservoir on the Rabagao River. Further diversion works were to be built to lead from a reservoir near the confluence of the Cavado and Pitoes rivers, to give a further installation of 60MVA, and it is this stage of work for which the new Francis machine was installed last year. It may be recalled that the gross head of the earlier section of Vila Nova power station was 415m (1360ft) and three horizontal shaft, four-jet impulse turbine sets with twin overhang runners were installed.

The Charmilles concern also installed during the year two high head Francis machines, built generally along similar lines to the Vila Nova turbine, at the St. Leonard power station in Switzerland. Each of these vertical shaft machines has an output of 21,250 h.p., a maximum net head of 1345ft, and operates at the unusually high speed of 1000 r.p.m.

Technical Reports

Effect of Arcing on the Air Flow through the Nozzle of Gas Blast Circuit Breakers (*Summarising Report*) (Ref. G/T296). By A. A. Hudson. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 21s., postage 5d.—This report is a summary of investigations into the influence of the arc upon the air flow in the nozzle electrode of an axial-flow air blast circuit breaker. The mass flow of air through the nozzle during arcing and the static pressure at three points within it have been measured. The use of the mass flow ratio during arcing as a criterion in determining similar arc quenching conditions shows that this ratio may be expressed empirically as a function of the quantity $(I/d^{1\cdot5}p^{0\cdot5})$. There is a critical range of this quantity in which a mixture of clearances and failures occur, and which separates the region of clearances from that of failures. Regarding the centre of the critical range as the mean critical value of the ratio $(I/d^{1\cdot5}p^{0\cdot5})$, it is possible to correlate this quantity with switch and circuit variables other than I, d and p. So far, these variables include the rate of rise of restriking voltage and the distance between the nozzle and upstream electrodes (lower gap). The possibility of extending these relationships to conditions outside the range covered in the laboratory has been checked against available experimental data. The nature of the air flow during arcing, from the arc chamber to the nozzle and thence to the atmosphere, is discussed, and the conditions leading to a reversal of flow at the nozzle entry are considered.

Method for the Detection of Toxic Gases in Industry, Leaflet No. 4, Benzene Vapour. Second edition. Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2. Price 1s.—This is the second edition of the original leaflet on benzene vapour published in 1938. It describes a new method of test and the apparatus required for determining the presence and amount of benzene in industrial atmospheres. The test is still based on the use of a formolite reagent and the assessment is made by comparison with a standard colour. An improved form of bubbler has, however, been designed to make the test more sensitive. Another feature of the revised test which makes for greater accuracy is the use of a standard rubber-bulb aspirator in place of the hand pump at present used. A new method of preparing the standard colour is also described.

Naval Construction in 1955

By RAYMOND V. B. BLACKMAN

No. II—(*Continued from page 28, January 6th*)

TWO more of the new aircraft direction frigates were also launched in 1955, the "Chichester" on April 21, from the Govan yard of the Fairfield Shipbuilding and Engineering Company, Ltd., Glasgow, who are also building a sister ship, the "Lincoln," and the "Llandaff," from the Hebburn-on-Tyne yard of R. and W. Hawthorn Leslie and Co., Ltd., Newcastle, on November 30th. Although the name-ship of the class, H.M.S. "Salisbury," was the first of all the twenty-six new construction frigates of the post-war programme to be launched, she is not yet completed. Laid down on January 23, 1952, in H.M. Dockyard, Devonport, she took the water on June 25, 1953, and main machinery manufactured by Vickers-Armstrongs, Ltd., Barrow-in-Furness, has been installed in her. The construction of these four aircraft direction ships is all-welded and largely prefabricated, and they will have highly developed electronic equipment for their very specialised role. With a displacement of approximately 1800 tons standard and 2185 tons full load, they have a length of 330ft between perpendiculars and 340ft overall, a beam of 40ft and a maximum draught of 10ft. They will be propelled by Admiralty standard range diesel engines aggregating 14,400 b.h.p., turning two shafts, and developing a speed of about 20 knots; and their armament will include two 4·5in dual-purpose guns, two 40mm anti-aircraft weapons and the squid triple-barrelled anti-submarine mortar. Armed as they are against surface, air and underwater targets, and equipped with such comprehensive radar apparatus, they are in large measure general purpose frigates as well as specifically fighter direction ships.

Submarines

The first submarine of post-war construction, H.M.S. "Explorer" (Fig 3), was completed towards the end of the year. When she took the water on March 5, 1954, she was the first submarine launched for the Royal Navy since the last of the wartime "A" class came off the stocks in 1947. Her only sister ship was launched on February 25, 1955, and named "Excalibur." Both of these new submarines, which are largely experimental, were built by Vickers-Armstrongs, Ltd., Barrow-in-Furness. They have a modern version of the usual battery and main motors for underwater propulsion, but in addition to their diesel-electric machinery both submarines are fitted with turbine machinery for which the energy is supplied by burning diesel fuel in decomposed hydrogen peroxide. This machinery was developed under the direction of the Admiralty by a special design team at Vickers-Armstrongs. The high test peroxide plant acts as a booster to the electric motors, giving higher underwater power and longer endurance. Of a new streamlined type designed to operate at increased submerged speeds, both vessels have a length of 178ft 1in between perpendiculars and 225ft 6in overall with a beam of 15ft 8in. They are fitted with the latest submarine escape arrangements, including the one-man escape chamber, and the latest breathing apparatus designed for escape purposes and recently perfected for use by the ships' companies in the event of emergency.

Four new and improved small submarines came into service in 1955, namely the "Minnow," "Shrimp" (Fig 4), "Sprat" and "Stickleback." All built by Vickers-Armstrongs, Ltd., Barrow-in-Furness, they have a length of 50ft 8in between perpendiculars and 53ft 10½in overall with a beam of 6ft 3½in. Propelled by diesel and electric machinery, they were designed for training and trials purposes to ensure that small submarine techniques should be developed.

Eight large submarines with conventional propulsion are under construction. The

Fig. 3—H.M. Submarine "Explorer" at launch on March 5, 1954, since completed. Diesel fuel burnt in decomposed hydrogen peroxide provides energy for turbines when high submerged speed is required

"Porpoise," "Rorqual" and "Narwhal" are being built by Vickers-Armstrongs, Ltd., Barrow-in-Furness, while the "Grampus" has been undertaken by Cammell Laird and Co., Ltd., Birkenhead, and the "Cachalot" is in hand by Scotts' Shipbuilding and Engineering Company, Ltd., Greenock, all three experienced and traditional submarine builders. Two more of the same class are reported to have been ordered from Cammell Laird and another from Scotts', to be named "Finwhale," "Sealion" and "Whale." They are expected to have a submerged displacement of approximately 2000 tons. There were originally to have been more units of the "Porpoise" class, but the project was dropped in 1953 when it was decided to go ahead with the development of atomic-powered submarines.

Minesweepers

According to the 1955-56 Navy Estimates fifty-eight coastal minesweepers of the "Ton" class were in course of construction; and by the end of the year the total number of this type of vessel launched had been brought up to sixty-three. All the units of this numerically big category of warships, of largely wooden construction, of which the names of ninety have so far been announced, have a displacement of 360 tons with a length of 140ft between perpendiculars and 152ft overall and a beam of 28ft 9in. They have an armament of one 40mm Bofors A.A. gun forward and two 20mm A.A. guns aft. Their speed of 15 knots derives from two shafts turned by diesels manufactured by Mirrlees, Bickerton and Day, Ltd., Stockport, or by D. Napier and Son, Ltd., Acton (Deltic engines), the main machinery having been standardised to simplify the maintenance problem. John I. Thornycroft and Co., Ltd., Woolston, Southampton, act as the parent firm for the 16 yards building this class of minesweepers.

Of the smaller type known as inshore minesweepers thirty-six were in course of construction as shown in the 1955-56 Navy Estimates, but these are sub-divided into two classes, the "Ham" class and the "Ley" class, those being the suffixes of the villages after which they were named. The many vessels of the "Ham" class, of which the names of seventy-five have been announced to date, are small warships of wooden construction with a displacement of 100 tons standard and 120 tons full load, a length of 100ft between perpendiculars and 106ft 5in overall and a beam of 21ft 2in. These new minesweepers are armed with a 40mm Bofors A.A. gun or a 20mm A.A. weapon forward. Propulsion is by diesels manufactured by Davey, Paxman and Co., Ltd., Colchester, or by Ruston and Hornsby, Ltd., Lincoln; Fodens, Ltd., Sandbach, Cheshire; or Ransomes, Sims and Jefferies, Ltd., Ipswich, under licence from Davey Paxman, all the main machinery being standardised. J. Samuel White and Co., Ltd., Cowes, Isle of Wight, is the parent firm for these inshore minesweepers which, under a widely spread allocation scheme wisely devised by the Admiralty that will be of immense value if larger numbers of these craft are needed in wartime, are being constructed by twenty-two smaller shipbuilding yards and

Fig. 4—H.M.S. "Shrimp," post-war midget submarine, completed in 1955

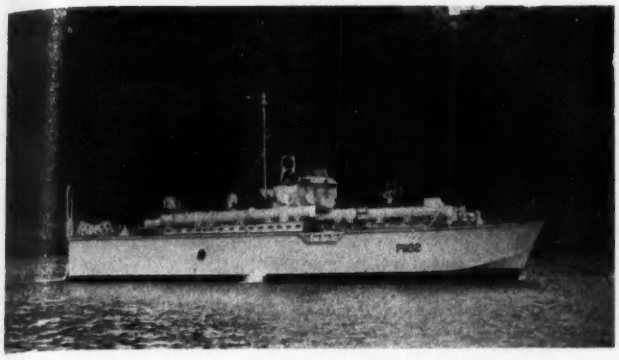


Fig. 5—H.M.S. "Dark Aggressor," convertible fast patrol boat, armed as torpedo boat ; completed 1955

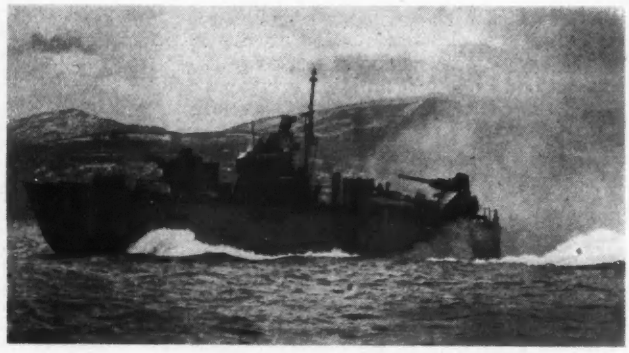


Fig. 6—H.M.S. "Dark Adventurer," convertible fast patrol boat, armed as gunboat ; completed 1955

boat and yacht building firms all over the United Kingdom.

The eleven inshore minesweepers of the "Ley" class differ from their half-sisters of the "Ham" class in that they are of composite instead of wooden construction and have a considerably modified layout and appearance as regards superstructure and equipment, while the dimensions are increased to 106ft 10in overall with a beam of 21ft 8in.

Patrol Boats

Several boats of the "Dark" class (Figs. 5 and 6) taken into service in 1955 (the class numbers eighteen units all with names prefixed by "Dark") are the latest fast patrol boats and the first class to be powered by the Napier "Deltic" engine, offering a very high performance. "Mosquito" warships of this type have been built for the Admiralty by various firms throughout the country under a group scheme, Saunders-Roe (Anglesey), Ltd., acting as parent firm to six other yards. The boats are of composite construction, aluminium alloy being used for the framing and for the deck. The hull is planked with two diagonal mahogany skins. These craft have a full-load displacement of 64 tons with a length of 67ft between perpendiculars and 71ft 4in overall, a beam of 19ft 5in and a maximum draught of 6ft 1in. The hull construction is of hard chine form, which has been developed to give good seagoing qualities combined with high maximum and cruising speeds. The boats are convertible—that is, they are constructed so that they can be armed at will either as gunboats or as torpedo boats, or for a dual role. In the gunboat guise they mount either a 4·5in gun and a single 40mm Bofors gun, or two single 40mm guns. In the torpedo boat role they are armed with four single above-water 21in torpedo tubes and a Bofors weapon. Rocket flare launchers and depth charge chutes are also fitted, and the boats are equipped with comprehensive radio and radar installations. Two Napier "Deltic" diesels aggregating 5000 s.h.p. give the "Dark" class motor torpedo/gun boats a speed of approximately 40 knots. The most remarkable feature of all these interchangeable gun/torpedo boats is the heavy calibre of the main gun that can be mounted for the size of the boat, the new type short 4·5in gun, 25 calibres in length, having been contrived on a platform of only 50 tons standard displacement.

Seaward Defence Boats

Six more of the novel submarine chasers of the "Ford" class, officially known as seaward defence boats, were accepted into naval service in 1955. All having place names with the suffix "ford," these handy patrol craft of a highly specialised type, intended for anti-submarine duties, have a displacement of 110 tons with a length of 110ft between perpendiculars and 117ft 3in overall and a beam of 20ft. Their armament includes a 40mm Bofors A.A. gun forward, depth charge release gear and flares ; modern electronic equipment is used in association with these weapons. The first boat was provided with a squid three-barrelled anti-submarine mortar aft. Others have depth charge rails and large and small depth charges, but all would doubtless be equipped with a squid in wartime. An entirely new design of naval vessel specifically designed for the purpose of detecting, locating and destroying submarines, including midget submarines, in the approaches to defended ports, they are powered with diesel engines and have comprehensive electrical installations which provide for electrical heating and cooking in addition to normal services. With finely streamlined twin funnels stepped athwartships, these seaward anti-submarine patrol craft have main propelling machinery manufactured by Davey Paxman and Co., Ltd., Colchester, and Fodens Ltd., Sandbach, Cheshire. They were built by ten concerns, with Yarrow and Co., Ltd., Scotstoun, Glasgow, acting as the parent firm for this new category of warships which have a sea speed of about 18 knots.

Fleet Train

The first of the Admiralty's new fast fleet replenishment ships, the "Tidereach" (Fig. 7), was accepted into Royal Naval Service from the hands of her builders, Swan, Hunter and Wigham Richardson, Ltd., Wallsend-on-Tyne, on August 30, 1955, the main machinery having been manufactured by the Wallsend Slipway and Engineering Company, Ltd., Wallsend-on-Tyne. She was launched on June 2, 1954. Two sister ships took the water in the following months, the "Tiderange" on July 1, 1954, at the Sunderland yard of Sir James Laing and Sons, Ltd., and the "Tiderace" on August 30, 1954, also at a Sunderland yard, that of J. L. Thompson and Sons, Ltd., the main machinery of both vessels being installed by the North Eastern Marine Engineering Company, Ltd., Wallsend-on-Tyne. A fourth ship of the class, the "Tide Austral," was built for the Royal Australian Navy by Harland and Wolff, Ltd., Belfast, being launched on September 1, 1954, and completed in March, 1955. This new class of ships represent a modern trend in the design and role of the Royal Naval Fleet Train. The purpose of these big fleet attendant supply vessels is the support of the operational warships and the replenishment of their supplies under way at sea. They are therefore fast and capacious, carrying 15,000 tons of fuel cargo, and fitted with the most modern handling gear for transferring food, stores, ammunition, oil and jet aircraft fuels by jackstay and derrick to ships needing them. The oil cargo can be subdivided into five different categories, all capable of being discharged at extremely high rates to ships on either beam or astern and while steaming at high speed. With a displacement of 15,000 tons standard and 26,000 tons full load, and a measurement of 17,700 tons deadweight and 11,200 tons gross, they have a length of 550ft between perpendiculars and 583ft overall, a beam of 71ft and a loaded draught of approximately 32ft. All the ships are powered by double reduction geared steam turbines capable of developing 15,000 s.h.p. and giving them maximum speeds in excess of 18 knots.

Reconstruction

Turning from newly-built ships to vessels being reconstructed, the large fleet aircraft carrier "Victorious," which is being com-

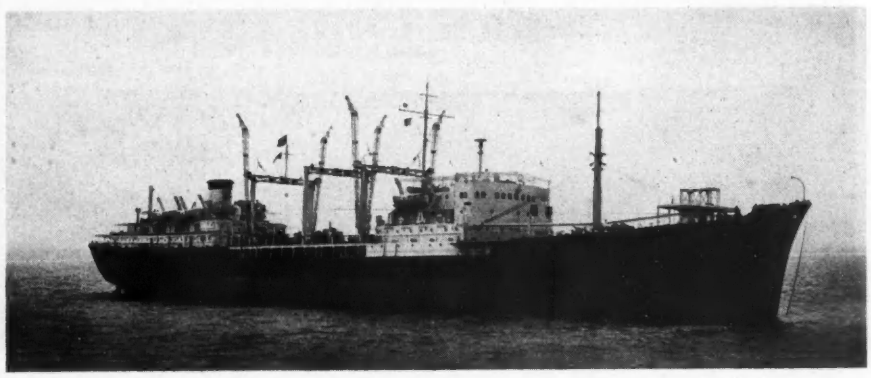


Fig. 7—R.F.A. "Tidereach," fleet replenishment tanker of 26,000 tons

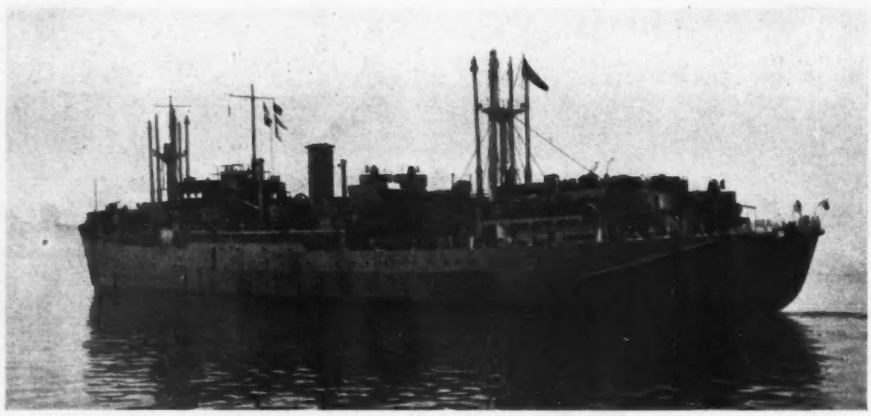


Fig. 8—H.M.S. "Girdle Ness" a landing craft maintenance vessel of 8580 tons now being converted for testing guided missiles

pletely rebuilt, was floated out of dry dock on May 19, 1955, for completion and fitting out in the basin. Her rejuvenation constitutes the biggest reconstruction project ever undertaken in Great Britain on a warship. She was taken in hand by H.M. Dockyard, Portsmouth, in March, 1950, but her conversion and modernisation is so extensive and so many new features are being incorporated in her to keep abreast of current and also anticipated developments, which will enable her to operate the largest, fastest and heaviest types of naval aircraft of the present and future, that she will not be completed until the end of 1957. She will be much longer, wider, higher and heavier than before, and will be equipped with the full angled deck, two of the new steam catapults, a deck edge lift in addition to central lifts, the recently invented mirror deck landing aid, new type of arrester gear, and improved hangars. When her transformation is completed she will be, to all intents and purposes, a new warship, and an aircraft carrier of a much more formidable type. The "Victorious" was originally laid down in 1937, launched in 1939 and completed in 1941 by Vickers-Armstrongs, Ltd., Walker-on-Tyne, with propelling machinery by the Wallsend Slipway and Engineering Company, Ltd., when she had a standard displacement of 23,000 tons with a length of 751ft, a beam of 95ft 9in and a draught of 29ft 3in. She was armed with sixteen 4·5in guns and over ninety smaller anti-aircraft guns; she had a capacity of fifty-four aircraft. Six three-drum boilers and Parsons geared turbines turning three screws and developing 110,000 s.h.p. gave her a speed of 31 knots. Her reconstruction involves increases of 7000 tons in displacement, 35ft 6in in length, 7ft 9in in hull beam, and 1ft 9in in draught. When she emerges from dockyard hands she will have an estimated displacement of 30,000 tons with a length of 786ft 6in, a water line beam of 103ft 6in, and a draught of 31ft.

The former landing craft maintenance ship "Girdle Ness" (Fig 8) is being converted into a guided missiles experimental ship. She originally had a displacement of 8580 tons with a length of 439ft, a beam of 62ft and a draught of 29ft. The reconstruction of this ex-repair ship is being undertaken in H.M. Dockyard, Devonport. She will have a full superstructure with an enclosed bridge extending the full width of the ship, two tall lattice masts of equal height, and two guided missile launching platforms in "X" and "Y" positions aft. There may be a launching platform in "A" position forward. The conversion of the "Girdle Ness" is scheduled to be completed ready for the ship to carry out trials by June, 1956.

Of the fleet destroyers of the war emergency classes scheduled to be converted into fast anti-submarine frigates, thirty-three had been reconstructed or were nearing the completion of their conversion by the end of 1955. These rebuilt vessels are divided into two types, one being fully converted into specialised hunter-killer frigates, involving complete reconstruction and leaving little resemblance to the original destroyer category, and the other type entailing limited conversion into fast anti-submarine escorts, utilising the basic layout and preserving much of the appearance of the orthodox destroyer. The twenty-three 1st Rate frigates, fully converted, like the "Urania" (Fig. 9), commissioned in 1955, are armed with two 4in guns in a twin mounting in "Q" position, firing over the shelter deck and quarter-deck, two 40mm Bofors A.A. guns surmounting the forward superstructure between the bridge and the foremast, and two Limbo three-barrelled anti-submarine mortars arranged *en echelon* in "X" position. The seven limited conversions from destroyers, of which the "Terpsichore" (Fig. 10) is a recent example, are armed differently, with two 4in guns in a twin housing before the bridge in "B" position, seven 40mm Bofors A.A. guns, four 21in torpedo tubes in "Q" position in a quadruple mounting (the forward bank of four tubes having been suppressed), and two squid three-barrelled anti-submarine mortars in "X" position. All the above thirty ships have two Admiralty type three-drum boilers and two sets of Parsons geared turbines of 40,000 s.h.p., designed to give maximum speed of 36·75 knots; all originally displaced 1710 tons standard and 2500 tons full load. In addition, three somewhat smaller destroyers of 1540 tons standard and 2400 tons full load displacement with a speed of 34 knots, have undergone limited conversion into 1st Rate anti-submarine frigates with similar armament, the most recent representative being

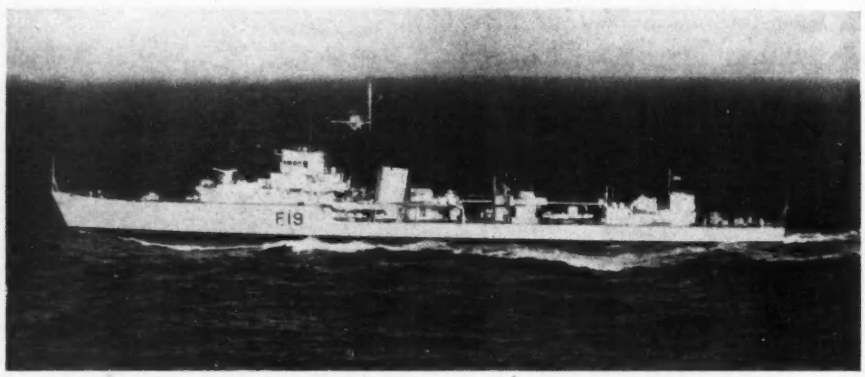


Fig. 10—H.M.S. "Terpsichore," converted from a destroyer to a fast frigate—limited conversion

Fig. 9—H.M.S. "Urania" fully converted from a destroyer into a fast anti-submarine frigate. Commissioned 1955

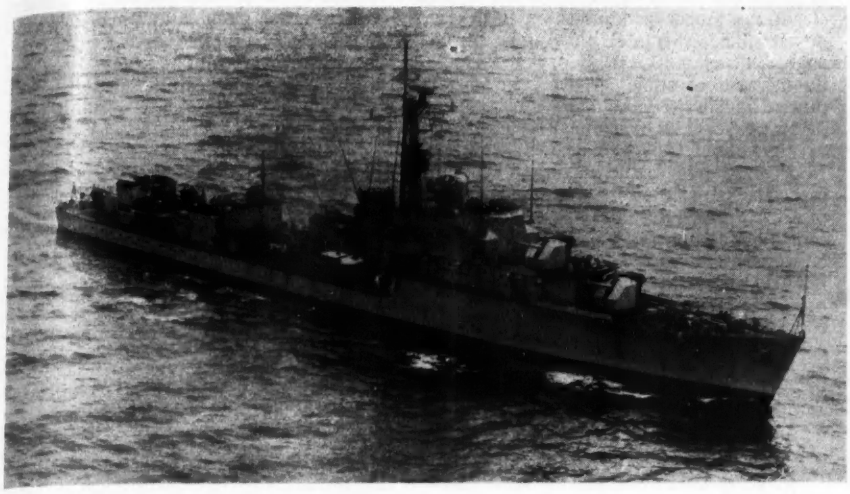


Fig. 11—H.M.S. "Carron," fleet destroyer reconstructed and modernised for anti-submarine warfare

the "Petard," which has just been completed.

An equally effective form of conversion to fast anti-submarine fleet escorts, and a more exciting one from the ascetic construction point of view in that, while it embodies most recent scientific developments and improved naval architecture, it has not involved reduction from the destroyer category or detracted from their appearance, is exemplified in the complete modernisation of several vessels of the "Ca" class destroyers, of which H.M.S. "Carron" (Fig. 11) is in commission. The after bank of torpedo tubes and the 4·5in gun in "X" position have been suppressed, but two squid triple A./S. mortars with weapon-handling room, improved control positions, radar and radio cabins, and new bridge, have been added, and the continued superstructure from the quarter deck to nearly amidships is reminiscent of the layout of a light cruiser. The new design and arrangement of these "Ca" class ships has been most cunningly contrived and reflects great credit on their progenitors, for in effect the vessels, without reduction of status from destroyers, now have almost everything. They are multi-purpose vessels which, with their three modern 4·5in guns in "A," "B" and "Y" positions, retain much of the surface-fighting power of the destroyer, but at the same time, with their new A.A. guns, squids and tubes, are also anti-aircraft vessels, anti-submarine escorts and torpedo boats. In some respects they are comparable with the limited conversion fast anti-submarine frigates, although in this case the destroyer designation has been retained. With a length of 362ft 9in, a beam of 35ft 9in and a maximum draught of 16ft, their displacement and propelling machinery are similar to those of both the fully converted and limited conversion fast frigates.

A number of the fifteen submarines of the "A" class completed in 1945-48, the biggest in the Royal Navy, are being reconstructed and modernised on similar lines to the American "Gupp" type (greater underwater propulsive power). These boats originally had a displacement of 1120 tons standard, 1385 tons on the surface and 1620 tons submerged, with a length of 221ft between perpendiculars and 281ft 9in overall, a beam of 22ft 3in and draught of 17ft. They were armed with a 4in gun, seven to nine smaller guns and ten 21in torpedo tubes. Their propelling machinery comprised diesels of 4300 b.h.p., for a surface speed of 19 knots, and electric motors of 1250 h.p., for a submerged speed of 8 knots. The "Artful" (Fig. 12) was the first of the class to be converted in 1955, and nine sister ships are in hand or are scheduled for reconstruction. She has been streamlined to give higher speed and better general performance under water. A dome built on forward contains detection and location gear, and the periscopes, schnorkel tube breathing mast, standards bridge and conning tower have been enclosed in one big streamlined fin housing all extraneous antennæ. The bows have been extended into a flush-decked forecastle and cutwater prow. The most conspicuous features of the transformation are the height of the conning arrangements atop the huge fin-like superstructure, and the superstructure forward built up into a cruiser type bow.

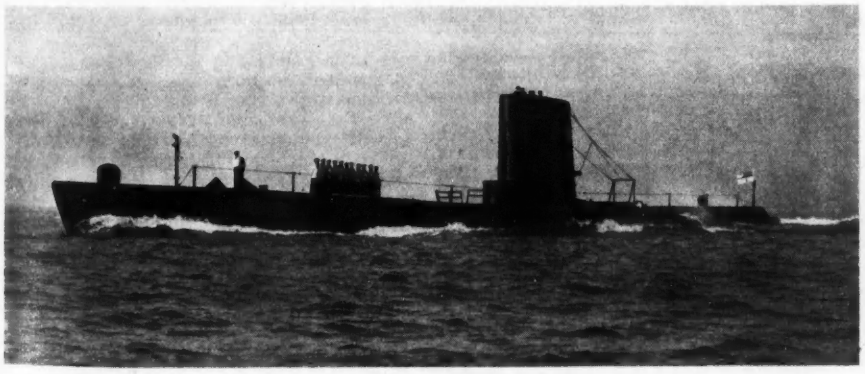


Fig. 12—H.M.S. "Artful," first of the post-war submarines to be reconstructed and streamlined, completed 1955

A most unusual conversion in 1955 was that of H.M.S. "Protector" from a fleet netlayer into a special service warship for the Antarctic. She was reconstructed and refitted to combine the multiple roles of frigate, guardship, helicopter carrier, icebreaker, surveying vessel, troopship and research vessel. Originally completed by Yarrow and Co., Ltd., Scotstoun, in 1936, the "Protector" (Fig. 13) has a displacement of 3000 tons standard and 3690 tons full load, with a length of 310ft between perpendiculars and 338ft overall, a beam of 53ft and a maximum draught of 15ft. She is armed with two 4in guns in a twin mounting forward, four 20mm Oerlikon anti-aircraft guns and four three-pounders. Two Admiralty three-drum type boilers and Parsons geared turbines developing 9000 s.h.p. give her a comparatively high speed of 20 knots. The ship was re-engined in 1945. During her conversion at H.M. Dockyard, Devonport, last year she was equipped with a "haystack" hangar aft to house two naval helicopters, adjacent to a landing deck erected over the quarter deck. Under the flight deck was sited the Royal Marine Barracks. While the helicopter garage was being erected and the landing and handling apron laid on aft, the main armament was moved from aft to forward, the secondary armament was halved and redisposed, the three-pounders were added, and the bridge and lookout were enclosed. New heating pipes were laid through the ship to all living, working and navigating spaces, among other alterations. The "Protector," being a

Fig. 13—H.M.S. "Protector," armed fleet netlayer reconstructed and converted to a multi-purpose frigate, helicopter carrier, guardship, troopship, research and surveying vessel and icebreaker for Antarctic service in 1955

warship, heavier than our largest destroyer and approaching the size of a light cruiser, with a particularly wide beam in relation to her length, she is very commodious and is thus eminently suitable for her special duties, accommodating more men and more equipment than the average frigates formerly employed on the station which were not strengthened against ice like the "Protector." As opportunity offers she will carry out scientific work on behalf of the Hydrographer of the Navy.

A smaller, but no less interesting reconstruction project was the conversion of the former steam gunboat "Grey Goose" into a gas turbine fast patrol boat. Two experimental Rolls-Royce "RM.60" marine gas turbine engines of advanced design have been installed in her and they transmit their power through Rotol controllable pitch propellers which obviate the use of reverse gearing. The work of structural alteration, as well as the installation of turbines, propellers, shafting and electrical equipment was carried out by Vospers, Ltd., of Portsmouth, at its Camber shipyard in association with Rolls-Royce and Rotol. Her conversion was extensive, the reconstruction amounting to building up from an almost bare hull. The accommodation between decks was completely altered and the necessary generators and navigational arrangements installed. The "Grey Goose" was originally powered by two Metropolitan-Vickers single-reduction geared turbines aggregating 8000 s.h.p. and of a design which represented the lightest steam machinery produced for naval purposes. The two "RM.60" gas turbine engines develop 10,800 b.h.p. and this gives an increase of some 35 per cent in total power, which is combined with a reduction of 50 per cent in machinery weight and a saving of about 25 per cent in machinery space. In order to achieve the maximum economy, especially at part powers, selection was made of a cycle which includes one axial and two centrifugal compressor stages with intercooling between stages. Located in the exhaust system is a heat exchanger which can be by-passed in order to obtain satisfactory power in tropical conditions; 2000 hours of running were carried out on the test bed at Rolls-Royce's Derby works, and sea trials lasting a period of nearly a year were run in the hands of the main contractors, Vospers. Now that the "Grey Goose" has been handed back to the Royal Navy—she was completed in 1955, being commissioned on June 22nd—further rigorous trials are being carried out, but already much valuable experience has been obtained and a considerable step forward in marine gas turbine technology has been achieved. It is significant that two "RM.60" gas turbines have been purchased by the United States Navy for installation and evaluation in a much bigger warship, the destroyer escort "Mills." These gas turbines cannot be reversed. The controllable pitch propellers not only provide for reversing, but also for selecting the optimum pitch for condition of boat speeding and loading. The propeller pitch is automatically locked, and cannot be altered above 600 s.h.p., at the full ahead position. Below this power, however, any pitch can be selected.

(To be continued)

Generating Plant Commissioned by the C.E.A. in 1955

THE Central Electricity Authority states that the new generating plant installed by the Authority during the year ended December 31, 1955, yielded an additional output capacity of 1721MW. This total compares with 1431MW installed in 1954, and 1539MW in 1952, the previous highest annual total.

The additional plant in 1955, comprising thirty-nine turbo-generators with an aggregate installed capacity of 1817MW, and fifty-six boilers having an aggregate evaporative capacity of 18,660,000 lb per hour, together with twelve diesel-engined generators with an installed capacity of 21·05MW, was installed in forty of the Authority's power stations. Seven of the forty are new stations in which plant was installed for the first time, and they are shown with an asterisk in the accompanying table which contains a list of the main items of plant.

Included in the figure of 1721MW is 56MW sent out in respect of two sets in the Clyde's Mill power station, which, at April 1, 1955, vested in the South of Scotland Electricity Board.

Generating Plant Commissioned by the Central Electricity Authority in 1955

Name of power station	Divisions	Turbo-generator plant		Boiler plant		Main high-pressure pipework
		Installed capacity in MW	Maker	Capacity in klb/hr	Maker	Maker
Steam plant :						
Acton Lane "B"	London	1×30	Richardsons, Westgarth	1×240	Mitchell	Aiton
Battersea "B"	London	—	—	2×425	Babcock and Wilcox	Aiton
Blackburn	North Western, Merseyside and North Wales	—	—	1×150	Simon Carves	Babcock and Wilcox
Brighton "B"	South Eastern	1×52·5	Richardsons, Westgarth	2×320	Babcock and Wilcox	C. A. Parsons
Brimsdown "B" I.P.	Eastern	1×60	Richardsons, Westgarth	2×340	J. Thompson	Stewarts and Lloyds
Brunswick Wharf	London	1×60	Metropolitan-Vickers	—	—	C. A. Parsons
Carmarthen Bay	South Wales	2×60	Metropolitan-Vickers	5×240	Babcock and Wilcox	Stewarts and Lloyds
Carrington	North Western, Merseyside and North Wales	1×60	Metropolitan-Vickers	1×360	J. Brown	Stewarts and Lloyds
Clarence Dock	North Western, Merseyside and North Wales	—	—	1×350	Babcock and Wilcox	Stewarts and Lloyds
Clyde's Mill	South West Scotland†	2×30	English Electric	4×180	Yarrow	Stewarts and Lloyds
Connah's Quay	North Western, Merseyside and North Wales	2×30	C. A. Parsons	2×300	International Combustion	J. Thompson
Cowes H.P.	Southern	2×12·5	Brush	2×135	Daniel Adamson	Aiton
Doncaster "B"	Yorkshire	—	—	4×180	Mitchell	Aiton
Drakelow "A"	East Midlands/Midlands	3×60	English Electric	3×515	International Combustion	Aiton
Fleetwood*	North Western, Merseyside and North Wales	3×30	English Electric	3×300	Simon Carves and Richardsons, Westgarth	Stewarts and Lloyds
Goldington*	Eastern	2×30	B.T.H.	2×300	Clarke Chapman	Stewarts and Lloyds
Hackney "B"	London	1×30	C. A. Parsons	1×300	Simon Carves	C. A. Parsons
Huddersfield	Yorkshire	1×30	G.E.C.	1×180	Bennis	C. A. Parsons
Huncoat	North Western, Merseyside and North Wales	1×30	G.E.C.	—	—	C. A. Parsons
Ince	North Western, Merseyside and North Wales	2×60	G.E.C.	2×550	International Combustion	Babcock and Wilcox
Keadby	Yorkshire	1×60	C. A. Parsons	1×550	Stirling/Babcock and Wilcox	C. A. Parsons
Littlebrook "C"	South Eastern	—	—	1×360	International Combustion	C. A. Parsons
Marchwood*	Southern	1×60	English Electric	1×550	J. Thompson	J. Thompson
Meaford "B"*	Midlands	1×60	B.T.H.	1×515	Babcock and Wilcox	Babcock and Wilcox
Portishead "B"*	South Western	1×60	Metropolitan-Vickers	2×300	Mitchell	Stewarts and Lloyds
Skelton Grange "A"	Yorkshire	1×60	C. A. Parsons	1×550	International Combustion	Aiton
Staythorpe "A"	East Midlands	1×60	B.T.H.	2×240	Babcock and Wilcox	Babcock and Wilcox
Stella North*	North Eastern	2×60	C. A. Parsons	2×550	Clarke Chapman	C. A. Parsons
Stella South	North Eastern	2×60	C. A. Parsons	2×550	Clarke Chapman	C. A. Parsons
Uskmouth "A"	South Wales	1×60	G.E.C.	2×360	Babcock and Wilcox	Aiton
Wakefield "B"*	Yorkshire	1×60	English Electric	1×550	Foster Wheeler	Aiton
Woolwich	London	1×30	G.E.C.	1×180	J. Thompson	C. A. Parsons
		39 Turbo-generators with a total installed capacity of 1817·5MW		56 boilers with a totalled installed capacity of 18,660klb/hr		
Diesel plant :						
Alderley Edge	North Western, Merseyside and North Wales	1×2	Mirrlees, Bickerton and Day			
Ashford "B"	South Eastern	3×2	Mirrlees, Bickerton and Day			
Basingstoke	Southern	1×1·05	Ruston and Hornsby			
Kendal	North Western, Merseyside and North Wales	2×2	Mirrlees, Bickerton and Day			
Macclesfield	North Western, Merseyside and North Wales	1×2	Mirrlees, Bickerton and Day			
Newbury	Southern	1×1·05	Ruston and Hornsby			
Southend	Eastern	1×0·95	English Electric			
Walsall	Midlands	2×2	Mirrlees, Bickerton and Day			
		12 Diesel sets with a total installed capacity of 21,050kW				

* New stations, in which plant has been commissioned for the first time in 1955.

† This Division vested in the South of Scotland Electricity Board with effect from April 1, 1955.

Nuclear Power for Commercial Vessels*

By K. MADDOCKS, B.Sc.Tech.†

WITH the worldwide increase in demand for power, which must accompany the present rise in the standard of living and the increase in population, some authorities have estimated that the limit of economical production of fossil fuels will be reached in about 100 years' time. The alternative sources of power being developed currently are nuclear and solar energy. While discussion in this paper will be confined to the former, it should be borne in mind that the present stage of development of the solar battery has produced an efficiency of the order of 10 per cent. This may well be bettered and applied to transportation within a decade.

Authorities contend that nuclear power production ashore can be competitive with fossil-fuelled power production in about ten years' time. It seems unlikely that a nuclear-powered marine plant will show any economical advantage before that time since one of the main factors will be the source of supply of fissionable fuel at a reasonable price and this must probably await the actual operation of a land power station using a breeder reactor. Probably one, and possibly two, nuclear-powered merchant ships will be in operation within the next five years. These will not be competitive in either first cost or operational cost with vessels propelled by orthodox machinery, primarily because of the inevitable expense attached to the development of any new type of machinery.

The U.S. Atomic Energy Commission has recently prepared estimates of the economically recoverable reserves of both conventional and nuclear fuels, an abstract of which is given in Table I :

TABLE I—*World Reserves of Fuel*

Fuel	World reserves	Energy in B.Th.U.
Coal	3482×10^9, tons	$72{\cdot}2 \times 10^{18}$
Oil	186×10^9, tons	$7{\cdot}6 \times 10^{18}$
Gas	560×10^{12}, cubic feet	$0{\cdot}6 \times 10^{18}$
	Total conventional	$80{\cdot}4 \times 10^{18}$
Uranium	25×10^6, tons	1700×10^{18}
Thorium	1×10^6, tons	71×10^{18}
	Total nuclear	1771×10^{18}

The future of any leading maritime nation may well eventually depend on the availability of reactor technology and production potential. It will also depend on the location of sources of fissionable material of which uranium is the most promising.

Theoretically, 1 lb of nuclear fuel, which has a volume slightly in excess of 1 cubic inch, if completely fissioned, releases energy equivalent to 43×10^9 B.Th.U., or approximately 1000 tons of fuel oil. It is not possible to arrange complete fission of the fuel. Only a fraction can be used before chemical treatment is required, due mainly to the inevitable simultaneous production of reactor "poisons." The transfer of such highly concentrated heat to a usable form of working fluid requires a complex system for coolant circulation. Critical control mechanisms, remote fuel handling, shielding and heat exchangers are also required. Many of these require entirely new concepts in design, due to the increased heat transfer rates and the variation in static and fluid mechanics involved. Radiation decay and corrosion and the properties of the many new materials now in use also present problems. The heat produced by fission is on the credit side of the ledger, while the three "by-products"—alpha, beta and gamma radiation—are on the debit side, as they require special shielding to prevent a health hazard.

All reactors to date have been designed to use either uranium 235, uranium 233 or plutonium 239 as fuel. Thorium 232 is a fertile material, which can be converted to a fissile material in a breeder type reactor. It is significant to remember that we are discussing the use of a metal as fuel. Uranium has a density 1·5 times that of lead, its melting point is about 2000 deg. Fah., it is malleable and ductile and can be readily machined or cast. The fact that when in powdered form uranium is highly inflammable has no connection with its use as nuclear fuel. In the homogeneous reactor, it is used in the form of a salt, uranyl sulphate, and dissolved to form a liquid fuel.

Natural uranium, U.238, contains only 0·7 per cent U.235 by weight ; the other two fuels, U.233 and Pu.239, must be produced artificially. The degree of enrichment of the fuel is the proportion of fissile U.235 to non-fissile U.238. The higher the enrichment the more efficient "burn-up" of the fissionable U.235 can be expected. The production cost of the fuel is in proportion to the degree of purity required. In the present state of the art, any of the fissile fuels discussed above are costly, although the prices are currently in control of government agencies, e.g. Atomic Energy Authority in Britain or Atomic Energy Commission in America. The price of fissile fuel should be considerably reduced when the breeder type of reactor is put into service for power generation ashore.

TYPES AND OPERATION OF NUCLEAR REACTORS

Reactors are classed as either "thermal," "intermediate" or "fast," depending on the energy level of the neutrons. In a "thermal" reactor, the neutrons are slowed down considerably by a moderator before continuing the fission chain reaction. When the moderating action allows a higher neutron energy level to operate, the reactor is said to be of the "intermediate" type. If no moderator is provided to slow down the neutrons, then the reactor is "fast" and in some cases a fuel diluent may be necessary to spread the nuclei and so decrease the thermal flux density. The form of the fuel, coolant and moderator create further classifications. In a homogeneous reactor, the fuel, coolant and moderator are mixed, often in liquid form. In a heterogeneous reactor, these are separated usually in solid form, which allows a definite geometric arrangement, e.g. round rods of fuel can be slipped into the moderator block.

A reactor is said to be regenerative if it replaces all or part of the fissioned fuel by creating new fuel from non-fissionable fertile material. If this replacement is equal to the amount of fuel consumed plus some excess, then the reactor is known as a breeder.

Unlike the oil-fired boiler furnace, where the fuel is pumped in, atomised and burnt in a continuous process, the nuclear fuel supply for a complete run between refuelling ports would be carried in the core of a reactor (this excludes the homogeneous reactor). The quantity of fuel so carried would be determined not only by an allowance for "burn-up" and an excess to overcome the effects of reactor "poisons" which are simultaneously produced when the fuel fissions, but also from the concept of providing an accumulation of fuel sufficient to produce and maintain criticality.

The reactor is said to be critical if at least one of the neutrons (two or three are produced with each fission) is available to split up another nucleus and thereby maintain the chain reaction. This neutron multiplication factor (usually denoted by k) therefore determines whether the reactor is critical or not. If the value of k is unity or above, then the reactor is critical, but if the value falls below unity, the reactor becomes subcritical and the chain reaction ceases.

As a fissile fuel has the property of continuously emitting neutrons, some means of adjusting the k value is required to prevent a spontaneous build up to criticality. This is provided by control devices which have a high capacity to absorb neutrons. In the heterogeneous reactor, these devices are usually in the form of rods and shims of either cadmium, cobalt, hafnium or boron steel alloys. The movement of the rods gives a coarse control and the shims a fine control of the neutrons. In the "cold" position, both rods and shims would be full in. The power level of the reactor is selected by the withdrawal of the rods a predetermined amount. Then the gradual withdrawal of the shims further increases the k value of the reactor until it becomes critical and the system gets under way. The control shims are also used to compensate for fuel "burn-up" during reactor operation.

An emergency control device can be fitted so that if a shut down is required both the control rods and shims are rapidly driven into the core and the reactor immediately becomes subcritical. This is known as the "scram" control.

Since operating personnel would normally be located in a control room without access to the "hot" reactor, the various operating factors, such as control rod position, strength of neutron flux and coolant flow, &c., must be measured and transmitted to the control room by various instruments. These individual signals must then be used to operate automatically the reactor in a stable condition at the power level required.

Possible radiation hazards in the form of gamma rays or escaping neutrons must be detected by an elaborate system of sensing instruments located both inside and outside the reactor. The marine installation would also require these instruments on the ship's hull and on the ventilating system and sanitary system.

The removal of the spent fuel and its replacement by new fuel requires the use of remote controlled handling gear such as the mechanical tongs controlled by a periscope sighting device. The major portion of the so-called "spent" fuel is fissile after chemical processing, and has a high salvage value. It would usually be removed from the ship and dumped in a tank of water to permit the fission product heat to decay to a tolerable level. Then, encased in a "coffin" of lead, it could be transported to the reprocessing plant. The disposal of the actual waste product must ensure that it does not become a health hazard.

SELECTION OF REACTOR FOR MARINE USE

The range can be narrowed by space and weight considerations and also from the fact that a plant capable of producing replacement fuel is precluded. Such a breeder reactor would require a far too extensive ancillary chemical plant and shielded material handling equipment to be accommodated on shipboard. The design of a suitable vessel must include provision for loading and discharging packaged fuel and waste material. To exploit fully the main advantage in reduction of fuel weight and to offset as far as possible the expected high first cost and fuel cost, a minimum of 15,000 s.h.p. is indicated.

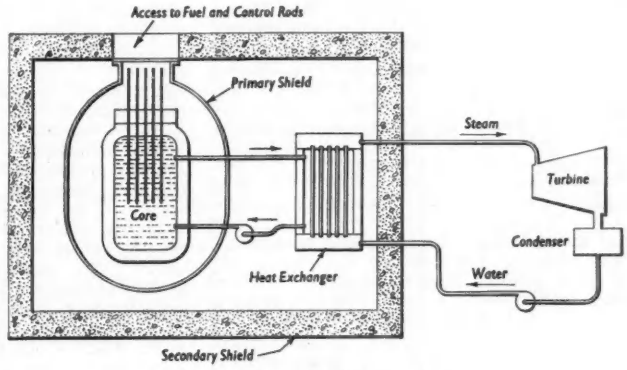


Fig. 1—Pressurised water reactor

The present monopoly of the steam turbine in this range of power, with the consequent accumulation of design and operating technique, has no doubt influenced the choice of steam as the working medium. It has been stated frequently that the only difference between a nuclear-fuelled steam plant and a fossil-fuelled steam plant is the type of boiler used. The operational control of the fluid conditioning unit (reactor) and the turbine must be more closely integrated than is the case even with

* Paper read before the Institute of Marine Engineers, December 20th. Abstract.

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advanced steam plants using automatic combustion controls.

A list of feasible types of reactor then becomes : Pressurised water reactor, boiling water reactor, homogeneous reactor, sodium loop reactor, gas-cooled reactor.

This list was computed from study of the U.S. Atomic Energy Commission's published five-year plan which, it is anticipated, will bring within sight the objective of harnessing nuclear power on a basis economically competitive with coal and oil. The first four reactors are versions of those included in the United States A.E.C. plan. The fifth will use a closed-cycle gas turbine as a power-producing unit, operating with helium as a working fluid.

Detail design of a particular reactor depends on the type of vessel in which it is to be used. The use of concrete for shielding is shown on all the reactors ; however, probably lead will be found to be the most suitable shielding material for marine use.

Pressurised Water Reactor.—The pressurised water reactor, as shown in Fig. 1, which is essentially as fitted in the U.S.S. "Nautilus," has become the "pioneer" marine plant. The fuel rods of the reactor could be of enriched uranium or plutonium, probably clad for strength with a metal, such as aluminium or zirconium. The control rods would be machined from a cadmium steel alloy or a boron steel alloy.

Highly purified water under pressure forms both reactor coolant and moderator to make the reactor operate at "thermal" energy level. For best heat transfer conditions in the reactor, the primary water velocity is increased by restricted passage cross sections. By maintaining a high rate of flow through the primary circuit, the temperature rise of the pressurised water is kept to a minimum. Heat is transferred from the primary circuit to the secondary circuit in a tubular exchanger and the steam so formed is separated in the steam drum of the steam generator.

One disadvantage of this system is the impracticability of producing superheated steam. As an example, assume the primary circuit water is pressurised to 1000 lb per square inch absolute, the maximum temperature in the primary circuit must be below the equivalent saturation temperature (544 deg. Fah.). Allowing 10 deg. Fah. loss during transmission to the heat exchanger and a mean temperature difference between the pressurised primary water and the evaporating secondary water in the heat exchanger of 60 deg. Fah., then saturated steam at 400 lb per square inch pressure will be produced. The United States A.E.C. reactor of this type will generate approximately 300,000kW of heat which will be transferred to the heat exchanger by circulating water at 2000 lb per square inch and 525 deg. Fah. Saturated steam at 600 lb per square inch pressure will be generated in the heat exchanger

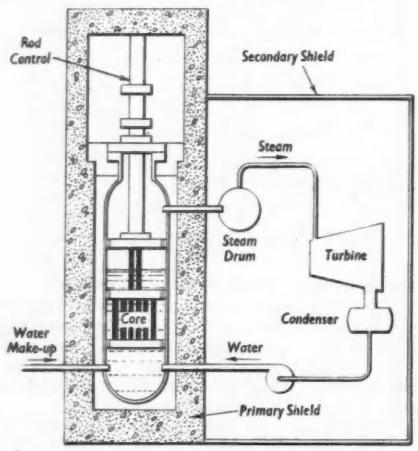


Fig. 2—Boiling water reactor

and passed to a steam-turbine generator which will have an output of some 60,000kW.

An inherent advantage of this system is that the expansion of water with temperature rise allows an increased leakage of neutrons and, hence, a system which to some degree is self stabilised. An improvement in neutron economy could be made by using heavy water instead of light water, and the thermal efficiency might be raised slightly by increasing the circulating water pressure. The principal bogey remains in the form of the efficient utilisation of saturated steam. Possible modifications to the modern steam turbine designed for superheat would be interstage extraction and centrifuging of the steam, the fitting of moisture throwing rings as blading shrouds, and it would appear necessary to use blading at the low-pressure end of the turbine, which has a high resistance to erosion.

Boiling Water Reactor.—Fig. 2 shows the boiling water reactor, in which steam is generated by direct contact during water circulation through the core. This is a simplification of the pressurised water reactor in that one of the loops is eliminated, but has two additional disadvantages. First, during the boiling process of the water, which acts as moderator as well as working fluid, the variation in density allows a variation in leakage of neutrons, thus causing a fluctuation in power level of the reactor. Secondly the steam passing off to the turbine will be radioactive, thus producing an additional shielding problem. It seems likely that the boiling water reactor would be operated at a lower power level than the pressurised water reactor. Experiments have confirmed that these reactors can give stable operation.

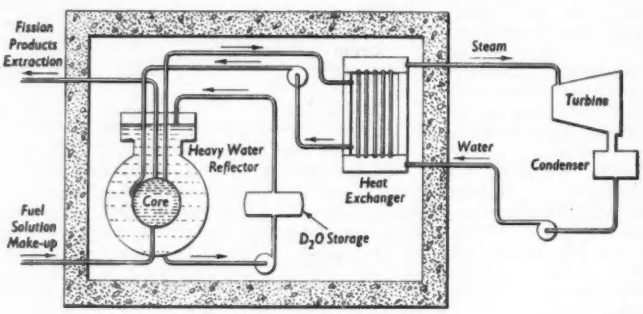


Fig. 3—Homogeneous reactor

Homogeneous Reactor.—The homogeneous reactor shown in Fig. 3 was designed to overcome the limitations of the heterogeneous reactor of which the two previous reactors are examples. These limitations are :—The separate core components of fuel, control rods, coolant and/or moderator in the limited area of intense heat create a real heat transfer problem ; the core structure is subject to radiation damage ; the accumulation of fission products caused by the absorption of neutrons necessitates the periodic removal of fuel for reprocessing. This, as previously discussed, is a complex operation.

The homogeneous reactor operates on an intimate mixture of fuel and coolant/moderator in the form of a solution of uranium salt in ordinary water. The primary circuit, through which this solution is circulated under high pressure, consists of the spherical container which forms the core and a restricted passage to the heat exchanger.

The form of the core is such that during passage through this sphere a sufficient accumulation of the solution occurs to reach criticality and the fuel will fission. During passage through the constricted circuit to the heat exchanger the spreading out of the solution will decrease the mass below the critical and so quench the chain reaction. Saturated steam which is not radioactive can be produced in the heat exchanger at reasonably high pressure.

The reactor core is surrounded by a neutron reflector of heavy water and arrangements are made for addition of fuel and removal of fission products while the reactor is in operation.

Control rods are not required as the system has been proved to be self-regulating ; e.g. with the main circulating pump stopped temporarily and the heat exchanger cooling down the uranium salt solution becomes more dense. On recommencing circulation the power output of the reactor shoots up until design level is restored. Then, by the time the solution reaches design temperature the solution has expanded to offset the reactivity and the power output levels off. Nuclear stability is purchased at the expense of providing a completely leakproof system for a highly radioactive and corrosive solution subject to a pressure of at least 1000 lb per square inch.

Sodium Loop Reactor.—Fig. 4 shows the variant in heterogeneous reactor design using liquid sodium as a coolant. A version of this type of reactor is to be used on the second nuclear powered submarine U.S.S. "Sea Wolf." Sodium being a weak moderating material, a separate moderator will be required and this could be of graphite block construction similar to the original piles at Harwell. For shipboard use the quantity of moderating medium required can be considerably reduced by designing the reactor for operating at an energy level above the "thermal." Sodium at atmospheric pressure has a boiling point of 1600 deg. Fah.; therefore the upper reactor temperature is not controlled by system pressure and large temperature variations in coolant can be arranged. While this leads to design prob'ems incurred in thermal stressing, it allows the production of moderately superheated steam (say, 600 lb per square inch and 800 deg. Fah.). The higher level of reactor power output increases the degree of radioactivity in the sodium and this provides a more difficult shielding problem than is encountered in a thermal reactor. Also the preparation of a sodium-cooled reactor for operation must include arrangements for external melting of the material prior to circulation in the system.

Another major potential danger is the possibility of leakage if the highly radioactive and strongly alkaline sodium were in close proximity to the steam system. Thus, the coolant system is separated into two stages to provide a partial solution. In the primary heat exchanger the radioactive sodium from the core gives up heat to non-radioactive sodium, which is then used to heat the secondary heat exchanger or steam generator. Another method of safeguarding against the contact of liquid sodium and water is the use of double-wall concentric tubing in the secondary heat exchanger. The annulus of this tubing could be filled with lead, giving a good heat transfer bond and a leak-detecting medium.

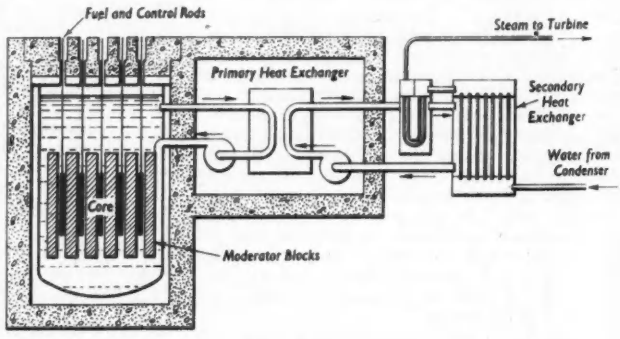


Fig. 4—Sodium loop reactor

Benzine has been suggested as a working fluid to replace steam, since it is chemically inert with sodium and the danger of a violent reaction resulting from any leakage is eliminated. How-

ever, perhaps benzine would not find favour because of the fire hazard introduced.

Probably the major engineering problem to be faced with this type of reactor is the pumping of a liquid metal at a temperature of about 1000 deg. Fah. Any leakage would produce both a radioactive and a fire hazard. A typical specification for leakage tolerance is 1 cubic centimetre in ten years, and to meet this demanding service two types of pumps have been developed. One is an electro-magnetic pump which eliminates the usual rotors and, consequently, the shaft glands ; the other is a centrifugal pump using fluid bearings.

Gas-Cooled Reactor.—The gas-cooled reactor is Britain's choice for development as a power

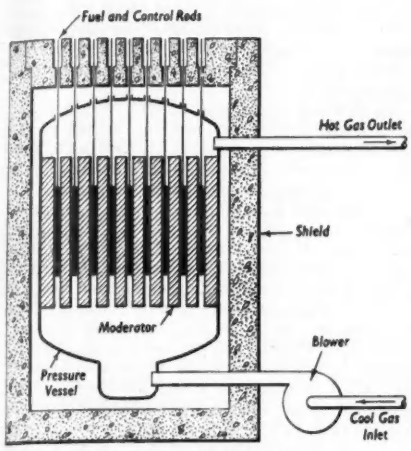


Fig. 5—Gas-cooled reactor

reactor ashore. This provides for the reactor coolant gas to circulate a steam generator. The steam produced, again probably saturated, with its attendant complications, would be utilised in a turbo-generator set.

The gas-cooled reactor shown in Fig. 5 is of the heterogeneous thermal type. The fuel could be slightly enriched uranium, the rods of which are clad with zirconium, aluminium or stainless steel to minimise neutron absorption. There is also the possibility of using fuel in powdered form sealed in a metal container, thereby reducing fuel reprocessing costs, although this could introduce a danger of failure of the fuel elements during operation. The moderator is provided in the form of block graphite or beryllium oxide and the control rods could again be of boron steel or cadmium.

Preliminary designs and outlines of equipment have been prepared for a submarine installation to compare the use of water, sodium and helium as coolants in the nuclear power plant. The characteristics are summarised in Table II.

TABLE II—*Comparison of Water, Sodium and Helium as Coolants*

Reactor coolant	Water	Sodium	Helium
Shaft power output	0·90	1	1
Overall plant weight	0·97	1	0·64
Specific weight, pounds per shaft horsepower	1·08	1	0·64
Space occupied, cubic feet per shaft horsepower	1·10	1	0·66
Shield weight	0·77	1	0·51

These figures appear to favour the use of helium, but their validity awaits confirmation.

Nuclear-Powered Closed-Cycle Gas Turbine Plant

The heat energy in the gas from the reactor can be directly converted to mechanical work in a closed-cycle gas turbine and while the working fluid could be either air, nitrogen, carbon-dioxide or helium, the latter is preferred. The steam generating and condensing equipment are thus eliminated, as are also make-up feed, boiler water conditioning and the many other ancillary problems connected with a modern steam plant.

Helium, if kept free of slight contamination during circulation, has a nucleus which is very stable under neutron flux, thus it does not become radioactive, as do air, nitrogen and carbon dioxide. In this type of plant only the reactor requires shielding, allowing a far more flexible machinery arrangement and a considerable saving in weight.

Helium has a better heat transfer characteristic than nitrogen, which is enhanced with increase in pressure. Thus, the heat transfer surface required will be reduced compared with an air or nitrogen system, but the high specific heat of helium makes the design of turbo machinery more difficult. The number of stages required for the same temperature rise is roughly proportional to the specific heat (1·25 B.Th.U. per pound for helium compared with 0·24 B.Th.U. per pound for air). However, the compressor temperature ratio required for maximum cycle efficiency decreases with increasing recuperator effectiveness and this fact is made use of in the design of closed-cycle helium plant by trading static heat transfer surface for stages of turbo machinery. The inert helium also removes the problem of chemical attack on the power plant components.

In common with most desirable commodities, the use of helium has one major snag—its cost.

Economic Aspects of the Use of Nuclear Fuel

A power of 15,000 s.h.p. has been mentioned as a minimum to fully exploit the advantages of the use of nuclear fuel. To illustrate the finance involved in powering a vessel to-day, estimates of propulsion machinery derived from the costs for five ships are given in Fig. 6. Costs include boilers, turbines, shaft and propeller, but do not allow for cargo handling machinery, steering gear, &c. In the power range pertinent to this discussion, the cost of the steam generators and auxiliary equipment is of the order of 20 per cent of the machinery costs indicated.

High-powered Cargo Ship.—An economic analysis has been made of the application of nuclear power to the "Mariner" class ships. These cargo vessels have a displacement of 21,000 tons and develop 17,500 s.h.p. to give a cruising speed of 20 knots. The maximum output is 19,250 s.h.p. and is, therefore, within the range considered feasible for nuclear powering.

The conclusion reached from the economic analysis was that it could not compete with the conventional power plants at present, but that the advance in reactor technology would improve the competitive position of this new power source. One factor which will adversely affect the suitability of this class of vessel for nuclear

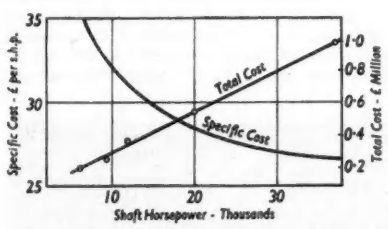


Fig. 6—Graph of cost estimates for steam turbine machinery

propulsion is its relatively low "load factor," determined from the number of days at sea and the power developed. The Harvard Report assumed 170 days at sea at 10,000 s.h.p. as typical for these ships. This gives a load factor of :—

$$\frac{10,000}{17,500}\times\frac{170}{365}=26\cdot6 \text{ per cent.}$$

The deficiency applies in some degree to all types of general cargo carriers.

Bulk Cargo Carriers.—A survey of the most desirable conditions under which to operate a nuclear-powered vessel gives a good indication of the type of vessel most likely to benefit from its adoption. As a first requirement, a high powered installation running on a long haul fully exploits the saving in oil fuel. Intermittent operation of a nuclear reactor is a wasteful procedure, as, at reduced loads, it is probable that arrangements must be made to "dump" the temporarily unused heat. Even on shut-downs, the reactor output can only be gradually reduced to prevent overheating. To minimise loss, berthing and cargo handling time must be reduced. Another consideration is the special terminal facilities necessary to handle radio-active material. A shuttle service with fixed terminal ports would thus be desirable. Bulk cargoes such as ore, grain or oil, are, therefore, indicated and the latter appears to be preferred, particularly as the offshore loading and discharge of oil cargoes is now an accomplished fact. This is an additional advantage both in reducing manœuvring time and in providing a safety measure by isolation.

The specific vessel selected as suitable for analysis in this paper has the following principal

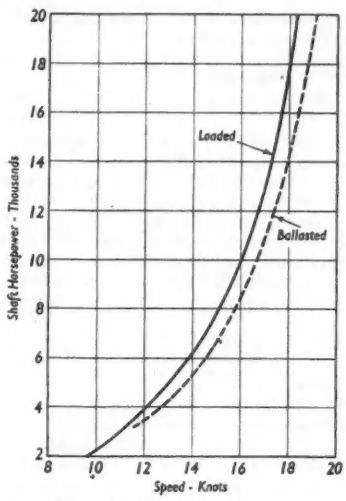


Fig. 7—Speed/power curves, loaded and ballast condition

dimensions : length overall 660ft, breadth 85ft, loaded draught 34ft.

The deadweight capacity loaded is 30,000 tons and the model test speed-power curve is reproduced in Fig. 7. The ballast condition curve was estimated from the model test data given, using the assumption that the speed of the ship in ballast would be 4 per cent higher than the loaded service speed. A comparison will be made between this ship and an equal sized vessel powered by a helium cooled reactor and a closed-cycle gas turbine.

A voyage from a North European port to either the Burma or Borneo oilfields will be considered a steaming distance of 10,000 nautical miles each way.

Reduced power operation during the voyage will be assumed as follows :—Suez Canal passage plus berthing at both ends, equivalent to twenty-four hours at 50 per cent service power ; loading and discharging equivalent to twenty-four hours at 15 per cent service power. The three cargo pumps fitted are actually each powered by 500 h.p. motors and are capable of discharging the rated cargo capacity in twelve hours.

The latest published performance figures for this tanker averaged over the outward and homeward passages of eight voyages, show a speed of 18·2 knots with a fuel consumption of 93·6 tons per twenty-four-hour day. This is higher than the predicted speed at the rated power of 16,500.

Estimate of Fuel Oil Consumption for Round Voyage

	Tons
At full speed $\frac{20,000\times93\cdot6}{18\cdot2\times24}$	4280
At reduced speed $\frac{8,250\times0\cdot6\times24}{2,240}$	54
In port $\frac{2,480\times0\cdot6\times24}{2,240}$	16
Total	4,350
Time for round voyage :	Days
At full speed $\frac{20,000}{18\cdot2\times24}$	46
Reduced speed and in port	2
Total	48

The comparison may be simplified if the cost of the turbines and transmission is considered to be the same in each case. The comparison then becomes one between the "steaming cost" of the orthodox ship and its equivalent with nuclear

powering. Fixed charges on the invested capital will be included. The cost estimate for the machinery of a 16,500 s.h.p. installation is £475,000, of which, say, £100,000 represents the cost of steam generators and ancillary equipment.

The following is the make-up adopted for the fixed charges on this type of investment :—

	Per cent per annum
Interest	2·6
Depreciation	4·9
Insurance	2·0
Maintenance	1·5
	11·0

Using these figures, the " steaming cost " for a round voyage would be :

Fixed charges $= \frac{48}{365} \times \frac{11}{100} \times$ £100,000 ... ... =	£1,450
Oil at 140s. per ton	£30,450
Total	£31,900

In calculating the fissile fuel consumption of the nuclear plant, the heating value of 1 gramme of U.235 is taken as $65 \cdot 5 \times 10^6$ B.Th.U., or equivalent to 25,750 horsepower-hours.

The cycle developed in the foregoing section will be used and the cycle efficiency of 42·4 per cent should not vary appreciably over the whole range of powers, this being a characteristic of the closed cycle plant.

Overall Propulsion Plant Conditions and Weight Flow

Net output (at shaft), shaft horsepower	16,500
Mechanical and other losses, per cent	5
Gross output, horsepower	17,350
Helium flow, pounds per hour $17,350 \times 9 \cdot 35$ ... =	162,000
Reactor load, B.Th.U. per hour $162,000 \times 514 \times 1 \cdot 25 = 104 \times 10^6$	
Overall propulsion plant efficiency, per cent : $\frac{16,500 \times 2,544}{104 \times 10^6}$	= 40·4

A 10 per cent addition to the turbine power output will be used to cover the engine-room auxiliaries.

Estimate of U.235 " Burn Up " During Voyage

	Grammes
At full speed ... ... $\frac{16,500 \times 1 \cdot 1 \times 46 \times 24}{0 \cdot 404 \times 25,750}$	= 1,927
At reduced speed ... ... $\frac{8,250 \times 1 \cdot 1 \times 24}{0 \cdot 404 \times 25,750}$	= 21
In port ... ... $\frac{2,480 \times 24}{0 \cdot 404 \times 25,750}$	= 6
Total	1,954

This is the weight of fuel which is actually destroyed in producing the power for the voyage but it only represents a fraction of the total fuel with which the reactor must be charged. A reasonable " burn up " percentage for the fuel for the heterogeneous gas-cooled reactor would be 25 per cent. Following this burn-up the fuel elements would require chemical processing. The capital outlay for the plant, therefore, must include the cost of some 5862 grammes of U.235 carried as dormant fuel per voyage.

A detailed estimate of the first cost of the gas-cooled reactor is outside the scope of this paper, but, using the limited information available, a figure of £1,000,000, or ten times the equivalent steam plant, agrees with majority opinion.

If the price of U.235 is £X per gramme and using the same fixed charges on investment the " steaming cost " for the voyage then becomes :

	£
Fixed charges = $\frac{48 \times 11}{365 \times 100}(1,000,000 + 5,862X)$	= 14,480 + 85X
Fuel at £X per gramme	= 1,954X
	14,480 + 2,039X

To " break even " with the equivalent orthodox steam plant, the cost of U.235 must then be :

$$X = \frac{31,900 - 14,480}{2,039}, \text{ say £8 10s. per gramme.}$$

At the international conference on the peaceful uses of atomic energy held in Geneva in August, 1955, the price of uranium was quoted at 25.00 dollars per gramme of U.235. It was not stated whether or not this figure included an allowance for fuel element fabrication. Even allowing for some error in this figure, with the present rate of exchange at 2·80 dollars = £1, then it would appear that a balance in " steaming costs " for the two plants could very nearly be made.

Additional Considerations in the Comparison.— The bunker fuel capacity of this 30,000-ton deadweight tanker is 4500 tons and would be filled at the port of loading. Using a nuclear-powered plant would increase the machinery weight by some 500 tons, giving a net increase in cargo capacity of 4000 tons. The crew wages of all classes of vessels are now a major item in operational expense. On completion of the initial voyage, it appears unlikely that any additional operating personnel will be required. For instance, the advances in reactor control technology have proved that such reactor controls are complex in design, but simple in operation. No account is taken of the additional investment to cover the charge of helium, but it is not expected that this would unduly affect the comparison.

The cost of the turbo machinery has been considered equivalent to that of the orthodox steam plant and a more detailed analysis would show a definite increase in cost for the helium machinery since more stages will be required. Also, special arrangements will be required to prevent leakages not only at glands and other openings in the casings, but also due to porous castings.

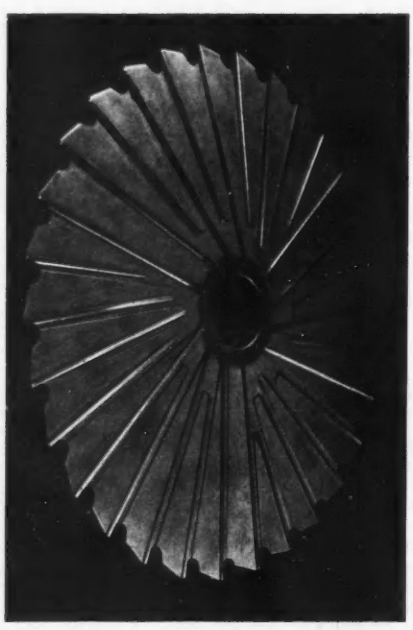
Conclusions

Following a study of the information now available on the various types of nuclear reactors and power plants, the author selected the helium-cooled reactor with a closed-cycle gas turbine power plant as the most attractive for commercial marine use. The economic comparison shows that this plant can compete with the oil-fired steam turbine plant for high-powered ships once the design values used in the paper have been verified in practice and the first cost of the plant proven to be of the order suggested. The latter will only be so when the components of the plant are in normal production by the equipment suppliers. On both counts, the time factor governs the date on which nuclear power will be adopted for ship propulsion.

Large Milling Cutter Gang

Some notes have been received from the English Steel Tool Corporation, Ltd., Manchester, of one of a number of very large milling cutter gangs the firm has supplied to Vickers-Armstrongs (Aircraft), Ltd., for machining high tensile steel aircraft component parts. The gang of cutters in question consisted of two 15·2in diameter single-angle cutters between which were set three 14·952in diameter double-equal-angle cutters. One of the double-angle cutters is illustrated below. They are thought to be among the largest solid high-speed steel cutters of their kind yet made in this country.

The important points in design in this gang of cutters were the angle of taper, the width of the cutters and the steps between the cutter diameters, which all had to be controlled to exceedingly fine limits ; furthermore, the double-equal-angle cutters were of a rather slender section, tapering from 1·050in wide to a tip with a radius of 0·18in.



Side view of 14·952in diameter double-equal-angle milling cutter. Three of these cutters between two single-angle cutters are used in a gang for milling high-tensile steel aircraft component parts

At the design stage it was decided that as the bulk of the material would be removed by the tip radius, it was necessary to provide at that point a positive cutting rake which, when continued down the sides of the cutter, would impart the necessary shearing action to the side teeth, the depth of the cut being approximately 6in. To give all the teeth a positive rake would have made an already awkward manufacturing proposition extremely difficult, so it was decided to have three equally spaced teeth radial, i.e. with no rake. This accounts for the uneven spacing and lengths of the teeth towards the centre of the cutter, which can be seen in the illustration.

In making the cutters careful attention was paid to the turning and milling operations and special gauges and equipment were used to keep to a minimum the amount of material to be removed at the grinding operation.

To facilitate grinding and inspection, a special inspection fixture was designed to check all the important dimensions of the cutters. This fixture incorporated a master base, bushed to accept a cutter whilst still mounted on a specially designed precision grinding arbor, and a sliding taper gauge which checked the angle of taper. The cutter chordal widths were controlled by measuring with block gauges the distance between the end of the taper gauge and the arbor. Grinding of the cutters was the most difficult operation, for not only had they to be ground to size, but they had then to be sharpened to produce a cutting edge without reducing the dimension.

Sluice Gates of the Ghulam Mohammed Barrage

In our issue of December 9th last, we printed a description from our Indian correspondent of the Ghulam Mohammed barrage at Kotri (Lower Sind), on the Indus River, in Pakistan. We have been informed that all the main barrage and canal head sluice gates, the lock gates and the lift bridge with their supporting structures and operating gears, were of British design and manufacture, having been supplied by Ransomes and Rapier, Ltd., the company which was also responsible for their erection on site.

The main barrage spanning the River Indus is approximately 3000ft long and is fitted with forty-three sluice gates, each 60ft in span, 21ft deep and weighing 45 tons. The navigation lock through the barrage is also of 60ft span and the lock gates are 21ft deep at one end and 34ft deep at the other. The roadway across the barrage is carried on a lift bridge over the span of the lock so that ample head-room may be obtained when the lock is open for the passage of river craft. Canals at both sides of the barrage have headworks fitted with a total of twenty-eight gates. Some 5000 tons of steel were used on this important contract. The firm also supplied the gates for the equally important Sukkur barrage, 200 miles upstream of Kotri, which was opened in 1932.

Code of Practice

N.C.B. SURVEYING PRACTICE AND STATUTORY PLANS, PART II

The first volume of this publication of National Coal Board (Production) Codes and rules was designed to establish within the Board's organisation standards of practice and accuracy in surveying and in the preparation of certain statutory mine plans. This second volume extends the scope of Part I and sets out the styles which are to be adopted for operational as well as statutory plans. It covers the following : working plan of the mine, manager's plan, sketch plan, colliery surface plan, ventilation plan, rescue plans, fire-fighting plans, deputy's district plan, stone dust plans, shaft section, colliery development plan, progress plan, composite plan, pumping plan, compressed air plan, project plans: and concludes with an appendix chart showing method of deriving master tracings and photographic transparencies. Copies of the volume may be obtained from the Stationery Department, National Coal Board, Hobart House, Grosvenor Place, London, S.W.1. Price 15s.

Industrial and Labour Notes

Engineering Wages

As recorded in these notes in our last issue, there was a meeting, on December 29th, between the Engineering and Allied Employers National Federation and the Confederation of Shipbuilding and Engineering Unions to discuss the latest wage claim put forward by the Confederation on behalf of workers in the engineering industry. At that meeting, it will be recalled, the union leaders put in a demand for a 15 per cent increase on existing rates.

Last week the Engineering and Allied Employers National Federation issued a report of the proceedings at the meeting. The president of the Federation, Sir Percy Mills, referred to the statement made in the Treasury's *Bulletin for Industry* that, between 1948 and 1954, the wages bill in manufacturing industry had risen by 60 per cent, but that in the same period output had increased by only 33 per cent. Sir Percy also mentioned the reports of the United Nations Economic Commission for Europe, which indicated that the United Kingdom was losing markets to other countries and especially to Germany.

Sir Percy went on to say that the losses were most marked in electrical machinery. He added that the export prices of United Kingdom engineering products between the first quarter of 1954 and August, 1955, had risen more steeply than those of any other European manufacturing country. Some members of the Federation, Sir Percy went on to say, were already feeling the effect of the changes in world demand, and in those cases a general wage increase could not benefit employment. In some directions capital expansion plans were being deferred or cancelled owing to credit restrictions, although the effects of that would not become immediately apparent on account of the extent of existing order books. A general wage increase without increased output, Sir Percy said, would adversely affect those workers with high overtime and other earnings. It would react particularly badly on the many small firms in the engineering industry, which would be unable to afford higher wages by economising in manpower. Sir Percy urged the unions to adopt the proposal of the Court of Inquiry of February, 1954, which recommended the setting up of an impartial and authoritative body to consider wage claims in their economic context.

The Federation's full reply to the unions' claim has been promised for February 2nd.

Production Costs

Some comments on the current trend of production costs were made last week by Sir Walford Turner in his chairman's statement at the annual general meeting of Wrights' Ropes, Ltd. He said that, looking back over the past year, he felt that in all the circumstances the results of the company's activities had been better than appeared likely at one time.

But, Sir Walford added, one disturbing feature was the persistent rise in the cost of almost every item entering into the make-up of production and distribution. Everything possible was being done to hold down the costs of production and to give encouragement for greater productivity, but unless the present tendency was curbed operating margins were bound to be adversely affected. It was futile, Sir Walford said, to expect to compete in the world's markets with prices that were continually rising against the buyer.

Railway Staff Shortages

At the end of last week the National Union of Railwaymen stated that it had agreed to three of the four proposals put forward by the British Transport Commission for easing the shortage of labour on British Railways. The first of these proposals concerns extra lodging allowances to encourage the transfer of labour to areas, such as London and the Midlands, where the manpower problem is most acute. The existing allowance of £2 2s. a week is to be increased by £1 a week for an indefinite period. The second proposal is easier entitlement to free passes and privilege tickets as an incentive to railway staff recruitment, and the third proposal accepted by the N.U.R. is that the recruitment age for engine cleaners should be raised from twenty-five to thirty.

The Transport Commission's proposal which the N.U.R. has rejected is that footplate men should be permitted to remain at work after reaching the retirement age of sixty-five. The union says that acceptance of that proposal would discourage recruitment and hinder promotion ; but it does not object to footplate men over the age of sixty-five transferring to other jobs on the railways. The other railway union concerned, the Associated Society of Locomotive Engineers and Firemen, has not yet expressed its views on the Commission's proposals.

In an address to the Public Schools Careers Masters Convention on Thursday of last week, the Minister of Transport and Civil Aviation, Mr. Harold Watkinson, spoke about the opportunities for technical staff on the railways. He referred in particular to the scheme which is being prepared to provide bursaries enabling suitable boys at selected schools to continue at school in order to go on to a university with a view to entering the railway service. There really was a bright future for railway staffs, the Minister said, once the new development plans were under way.

Iron and Steel Import Duties

The Board of Trade has announced that, under the Import Duties (Exemptions) (No. 7) Order, 1955, the import duties on many iron and steel products have been suspended until March 18, 1956, while those on certain cold-rolled sheet are suspended until September 18, 1956. After consultation with the Iron and Steel Board about the supply position, the Government has decided to make a new Order which prolongs these temporary suspensions of import duty for a further six months, i.e. until September 18, 1956 (with an amendment to the description of plates and sheets to cover those imported in the form known as circles), and March 18, 1957, respectively. The new Order does not extend beyond March 18, 1956, the existing suspension of import duty on blast furnace ferro-manganese. The Government has undertakings from the producers and the main consumers of tinplate that all available home-produced tinplate, including the full output from the hand mills, will be taken up while the duty on tinplate and tinned sheets remains suspended. The new Order is entitled the Import Duties (Exemptions) (No. 11) Order, 1955, and came into operation on January 9th.

Admiralty Apprenticeship Scheme

A new apprenticeship scheme has been announced by the Admiralty, and details given of the regulations, for the entry of student apprentices in the Royal Dockyards and Aircraft yards at home. The announcement recalls that, before the second world war, most of the draughtsmen and subordinate technical officers for the Royal Dockyards and other naval establishments were obtained through a craft apprentice scheme, entry being by means of annual competitive examinations. Boys suitable to be trained as naval architects and electrical engineers were recruited from the same source. Changes in the national education system, shortage of manpower and higher standards of technical skill have meant, it is stated, that the post-war intake of technical and professional officers was below requirements. Therefore the existing scheme is to be supplemented by the recruitment of student apprentices, who will be trained to meet Admiralty requirements in the branches concerned. According to the announcement, the Civil Service Commission will conduct an examination in mathematics, physics, chemistry and English for candidates between sixteen and eighteen years of age, and those who satisfy the examiners will be given five years' training in Chatham, Devonport, Portsmouth or Rosyth dockyards. The course, it is stated, will impart basic knowledge of the building and repair of H.M. ships and give detailed training in naval construction, marine or electrical engineering. Both practical and theoretical instruction will be given and the announcement mentions that students who attain a proper standard by the end of the fourth year may be selected to receive advanced training with a view to entry into the Royal Corps of Naval Constructors, while one or more students may be trained as an electrical engineer. On the satisfactory completion of the course the students will be appointed as draughtsmen. The announcement states that the student apprentices examination will be held in April and copies of the regulations can be obtained from the Secretary, Civil Service Commission, Burlington Gardens, London, W.1.

Awards to Coal Board Employees

The National Coal Board has stated that, in the year ended September 30, 1955, it paid out nearly £14,000 in awards to employees who have produced technical inventions useful to the coal mining industry. These awards were made under a scheme introduced in March, 1952, as an incentive to workers in the industry, and its success, the Coal Board says, can be gauged by the fact that the number of awards is increasing annually.

The awards can be made by divisional panels or by the National Awards Tribunal, though the divisional panels can make awards of up to £100 only. Last year, the National Awards Tribunal made seventeen awards, totalling £10,300, and the divisional panels awarded a total of £3488 to 124 inventors. The scheme is open to all employees of the Board, but no award can be made for an invention produced by a research worker as part of his normal duties. The Board says that inventions have been submitted by people employed at all levels in the industry, and that, since the scheme started, over £34,000 has been paid out.

The Nickel Industry

Dr. J. F. Thompson, chairman of The International Nickel Company of Canada, Ltd., has reported that nickel production in the free world last year reached a record figure estimated at 427 million pounds, or about 40,000,000 lb more than in 1954. It is thought that Canada produced 347 million pounds last year, and that of the total production Cuba accounted for 7 per cent ; New Caledonia, 5 per cent ; Japan, 3 per cent ; U.S.A., 2 per cent, and various other countries, 2 per cent.

The total nickel supply of the free world, Dr. Thompson says, including commercial production and Government subsidised production, was distributed to the extent of approximately two-thirds to the U.S.A. and one-third to Canada, the United Kingdom and other countries. A substantial part of the distribution to the U.S.A. was used for defence production and stockpiling requirements. Dr. Thompson adds in his report that the increased tempo of industrial activity throughout Europe and North America increased the demand for nickel last year in every "established field of interest." There was slightly more nickel available for civilian use than in 1954, but the limitations in supply caused by large defence requirements and by the needs of the U.S.A. strategic stockpile continued to place a burden upon the expansion of civilian markets.

Throughout last year, the basic prices for Canadian nickel to industrial consumers in all world markets continued unchanged at 64½ cents U.S. currency (including the 1½ cents U.S. import duty), or the equivalent prices in Canadian and British currencies.

Personal and Business

Appointments

MR. E. F. WILKINS has been appointed a director of The Rheostatic Company, Ltd.

SIR GUTHRIE RUSSELL has joined the board of Henry Meadows, Ltd., Wolverhampton.

REAR-ADMIRAL (E.) I. G. MACLEAN has joined the Brush Group, Ltd., as director of marine development.

HEAD WRIGHTSON STAMPINGS, Ltd., states that Mr. George Jones, general manager, has been appointed a director.

A.P.V.-PARAMOUNT, Ltd., Manor Royal, Crawley, states that Mr. L. H. S. Halling, sales manager, has been appointed a director.

WILLIAM BEARDMORE AND CO., Ltd., states that Mr. Hugh R. Byers, sales manager, has been appointed special director.

MR. D. P. C. NEAVE, vice-chairman of Consolidated Zinc Corporation, Ltd., has been elected chairman of the Zinc Development Association.

THE STEEL COMPANY OF WALES, Ltd., states that, in due course, it will set up its own sales organisation and, accordingly, the Hon. Michael Layton has been appointed sales controller.

H. LEVERTON AND CO., Ltd., Spalding, Lincs, states that Mr. L. F. Everard has been appointed parts and service director. Mr. C. W. Bruce has been appointed parts manager at the Spalding depot.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, 17, announces the appointment of Mr. J. C. Anderson as traffic manager, in succession to the late Mr. Albert Mycoe.

MAVOR AND COULSON, Ltd., Bridgeton, Glasgow, states that Mr. J. D. Lloyd, sales director, has been appointed joint managing director, and that Mr. R. J. Hird, director and chief engineer, has been appointed works director

CANADIAN PACIFIC STEAMSHIPS, Ltd., announces that Mr. J. R. Y. Johnston, the present naval architect of the company, has been appointed general superintendent of construction and will continue to have his headquarters in Liverpool.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., announces the appointment of Mr. W. L. Munday as engineer-in-charge at the Croydon branch of the aeronautical division. He succeeds Mr. H. T. Sayer, who has retired after more than forty years in the company's service.

THE ASQUITH MACHINE TOOL CORPORATION, Halifax, states that Mr. W. G. Hunt and Mr. A. D. George have been appointed joint managing directors of Drummond-Asquith (Sales), Ltd., in succession to Mr. R. W. Asquith and Mr. G. E. Hickman. Both Mr. Asquith and Mr. Hickman continue to serve on the board of the company, the former as chairman.

THE BRITISH ALUMINIUM COMPANY, Ltd., states that Mr. W. B. C. Perrycoste and Mr. J. Salter are to become joint general production managers as from February 17th. These appointments follow the retirement of Mr. S. F. Derbyshire from the position of general production manager. He will continue as a consultant to the company for the time being. Mr. P. T. Ensor has been appointed general manager of The Canadian British Aluminium Company, at Baie Comeau, and Mr. A. R. Wylie has relinquished his post at the Lochaber works on becoming works manager designate of the Baie Comeau project.

Business Announcements

MR. S. F. DAVY has retired from the Dunlop Rubber Company, Ltd., after twenty-six years' service in the overseas division.

KEELAVITE ROTARY PUMPS AND MOTORS, Ltd., Allesley, Coventry, states that its telephone number has been changed to Meriden 441.

MR. T. L. KENDALL, sales director of Ruston and Hornsby, Ltd., is making a round-the-world tour which will extend over the next three months.

MR. C. J. WRIGHT has been invited by the Iranian Government to act as adviser on the expansion of existing refinery facilities in North West Iran.

THE NATIONAL COAL BOARD has announced the retirement of Mr. W. Reginald Picton, head of the conciliation branch of the industrial relations department.

THE BIRTLEY COMPANY, Ltd., Birtley, Co. Durham, has made an agreement with Calorific Appliances, Ltd., to manufacture the De Poray boiler at Birtley.

MAVOR AND COULSON, Ltd., Bridgeton, Glasgow, has announced the retirement of Mr. J. B. Mavor from the chairmanship. Mr. Mavor has served as a director of the company for thirty-five years.

A. C. WILSON AND PARTNERS, Ltd., Design House, The Mall, Ealing, W.5, has been appointed design consultant to the United Kingdom Atomic Energy Authority, Risley.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that its Leeds office is to be moved on January 17th to St. Paul's House, St. Paul's Street, Leeds (telephone, Leeds 20718).

TRIPLEX (NORTHERN), Ltd., states that it will this year occupy an additional 66,000 square feet of factory space in a new building near to its existing works at St. Helens, Lancs.

SIR HENRY WILSON SMITH has resigned from the board of Mobil Oil Company, Ltd., on account of the increasing pressure of his duties in the Powell Duffryn group and elsewhere.

THE BRUSH GROUP, Ltd., has made an agreement with Maybach-Motorenbau G.m.b.H., Friedrichshafen, Germany, to manufacture in the United Kingdom Maybach MD diesel engines.

THE BRUSH GROUP, Ltd., states that, owing to ill-health, Mr. S. A. Lane has retired from the board. His services will continue to be available to the company and its subsidiaries as a consultant.

MR. MILES B. REID has resigned from the board of Stephenson Clarke, Ltd., to enable him to devote more time to his directorships of Powell Duffryn, Ltd., Mobil Oil Company, Ltd., and other companies.

MAJOR CYRIL DENNIS states that Cyril Dennis and Associates has been formed to conduct an advisory sales consulting business at Morris House, 1, Jermyn Street, London, S.W.1 (telephone, Trafalgar 7393).

WILD-BARFIELD ELECTRIC FURNACES, Ltd., Watford, Herts, states that, from January 16th, the address of its N.W. England and North Midlands office will be 1, Clarkehouse Road, Sheffield (telephone, Sheffield 62784).

MR. J. E. GREATOREX announces that the consulting engineering practice of the late Mr. H. Q. A. Reeves will in future be carried on under the name of J. E. Greatorex and Partners, at 15, Berners Street, London, W.1 (telephone, Langham 1080).

TECALEMIT, Ltd., Plymouth, and Kerry's (Great Britain), Ltd., Warton Road, Stratford, E.15, have signed an agreement under which the latter firm becomes exclusive distributor in the motor trade of Tecalemit lubrication and vehicle servicing equipment.

SHEEPBRIDGE EQUIPMENT, Ltd., states that Mr. R. S. Harding, technical manager, has just completed a coast-to-coast tour of the U.S.A. The company has announced also that it has acquired the manufacturing rights in this country of the Schaffer poidometer.

THE BRISTOL AEROPLANE COMPANY, Ltd., has announced a reorganisation of its Canadian companies. The three operating companies at Montreal, Winnipeg and Vancouver are to be controlled by the Bristol Aeroplane Company of Canada (1956), Ltd., Montreal, which will be a subsidiary of the parent company at Bristol.

BAIRD AND TATLOCK (LONDON), Ltd., 14–17, St. Cross Street, London, E.C.1, has announced with regret the death of Mr. S. J. Matthews, head of the research and development division, which occurred suddenly on January 2nd. Sir Bernard Keen, F.R.S., is taking charge temporarily of the research and development division.

THE DUNLOP RUBBER COMPANY, Ltd., announces the formation of a separate division for the manufacture and sale of rubber hose in the United Kingdom. Mr. P. A. Bridge, hitherto sales manager of the general rubber goods division's mechanical group, is the manager of the new group, which operates at the company's works at Cambridge Street, Manchester.

THE GOODYEAR TYRE AND RUBBER COMPANY, Ltd., states that McNeill Engineering, Ltd., 78, Duncrue Street, Belfast (telephone, Belfast 45211), is now the sole distributor of its industrial rubber products in Northern Ireland. Rolkin-Shakeshaft, Ltd., 324, Deansgate, Manchester, 3 (telephone, Deansgate 7604), has been appointed sole distributor for N.W. England.

THE EXPANDED METAL COMPANY, Ltd., Burwood House, Caxton Street, London, S.W.1, has acquired the share capital of the Cressall Manufacturing Company, Ltd., Birmingham. The activities of the latter company will be co-ordinated with those of the electrical division of the Expanded Metal Company, Ltd. Colonel H. F. G. Langley, a director of the Expanded Metal Company, Ltd., and Mr. W. F. Knight, chief executive of the electrical division, have been elected to the board of the Cressall Manufacturing Company, Ltd.

Contracts

THE FAIREY AVIATION COMPANY, Ltd., states that its subsidiary, Air Survey Company, Ltd., has received a contract from the Persian Government, worth about £250,000. The work to be undertaken will include not only topographical mapping, but surveys for town planning, road, rail and pipeline construction, irrigation, hydro-electric schemes, ports and aerodromes, and geological exploration. It will, in fact, provide essential data for the general development of the whole of Persia. The contract appoints the Air Survey Company, Ltd., as consultant and contractor to the Persian Government and it requires the company to instruct Persian technicians in aerial photography and the preparation of maps from air photographs in Persia for the next two years.

Miscellanea

SYMPOSIUM ON NUCLEAR ENERGY.—The Institution of Mechanical Engineers has announced that, in conjunction with the British Nuclear Energy Conference, it will hold a symposium on nuclear energy on Wednesday, March 28th. The purpose of this symposium is to provide for mechanical engineers a sound educational introduction to the subject of nuclear energy. There will be four papers, followed by discussion.

TRAINING OF THE CHEMICAL ENGINEER.—A report of the International Conference, held in London from March 21 to 23, 1955, on the "Function and Training of the Chemical Engineer," has been published by the European Productivity Agency of the Organisation for European Economic Co-operation. The report includes summaries of the papers read and of the discussion and a summing-up of the conference by Sir Harold Hartley.

PALM END LUBRICATORS.—A lubricator now being made in two capacities by Centralube, Ltd., Great Western Trading Estate, Park Royal Road, London, N.W.10, is specially designed for lubricating the slipper and palm end of rolling mill spindles. This lubricator is fixed on and rotates with the spindle, and it is actuated by the reciprocating motion of an arm having a roller at one end which registers on a cam fixed to the supporting bearing of the spindle.

OFFICE MACHINERY.—The Office Appliance and Business Equipment Trades Association has announced that the next National Business Efficiency Exhibition is to be held at the Bingley Hall, Birmingham, from February 20th to 25th, inclusive. About 110 British firms will display their products, the area of stand space to be occupied being nearly 40,000 square feet. The Association says that, last year, exports of office machinery and equipment from this country averaged £1,750,000 a month.

ILLUMINATING ENGINEERING SOCIETY.—This year's summer meeting of the Illuminating Engineering Society is to be held at Harrogate, from May 8th to 11th. It is stated that the papers to be presented will emphasise "practical lighting matters." The programme will include visits to factories and a display of new lighting equipment. Participation in the meeting is not restricted to members of the Society. Details are available from the Illuminating Engineering Society, 32, Victoria Street, London, S.W.1.

THERMOSTATICALLY CONTROLLED DRUM FILLER.—A difficulty encountered when filling drums with fluids, such as at oil refineries and distributing plants, is the change in volume which occurs as a result of variation in fluid temperature. This presents a particular problem when fluid is being sold on a weight per volume basis. In order to overcome this problem what is known as the "Astral-Rockwell" thermostatic drum filler has been introduced by A. S. Ladley and Co., Ltd., 3, Crompton Way, Crawley, Sussex. In this device a thermostat is used to actuate a compensating mechanism which automatically adjusts the volume metering unit through which the fluid is measured, in accordance with the temperature of the fluid.

SCHOLARSHIPS IN NAVAL ARCHITECTURE.—The Institution of Naval Architects states that the following scholarships in naval architecture, which are tenable for three or four years, according to the length of the course at the university or college selected, will be offered for competition in 1956: "I.N.A.-Elgar-Martell," £275 per annum, age limit under twenty-three years, open to British subjects who have been employed for at least two years upon shipbuilding; "Vickers-Armstrongs," £220 per annum, age limit under twenty-three years, open to British apprentices or pupils in private shipyards. Entries for both scholarships close on May 31st next. Full particulars may be obtained from the Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1.

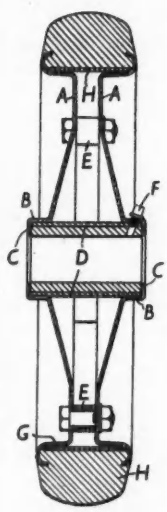
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

ROAD TRANSPORT

741,069. September 26, 1953.—RUBBER TYRED DISC WHEEL, Geo. H. Hughes, Ltd., Edgemond Avenue, Birmingham, 24. (*Inventor: Arthur Lumb Crawshaw.*)

The invention relates to an improved rubber-tyred disc wheel and is particularly applicable to castor wheels on industrial trucks where the wheel is subjected to forces tending to tear the tyre off. As shown in the drawing, the disc wheel is formed from two pressed steel discs *A*, each formed at its centre with an axially outwardly directed sleeve-like portion *B* terminating in a radially inwardly directed flange *C* surrounding an aperture at the centre of the plate. A hub *D* preferably formed as a pressed steel sleeve, is driven into the sleeve portion *B* of the one plate *A* and spot welded to prevent relative rotation, and the other plate *A* is then engaged with the opposite end of the hub *D* before the two discs *A* are bolted together. The bolts in addition to passing through the pair of discs pass through spacing sleeves *E* between the discs. One or both of the sleeve portions *B* of the discs may be drilled and tapped together with the hub *D* to accommodate a grease nipple *F* which additionally helps in preventing relative rotation between the discs and hub. Each disc adjacent its periphery is bent to accommodate an annular strip of steel *G* covering the gap between the two discs *A*. When the wheel has been assembled it is placed in a mould and a rubber tyre *H* is bonded to the annular strip, the rubber also filling the peripheral channels in the discs.—*November* 23, 1955.

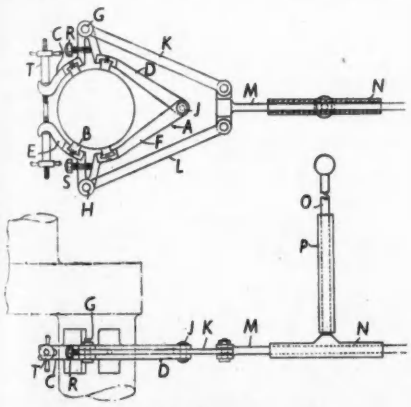


No. 741,069

MACHINE TOOLS

740,020. November 3, 1953.—GRINDING, LAPPING AND HONING DEVICE, John King Brown, 8, Buchlyvie Road, Ralston, Paisley.

The invention is a grinding, lapping and honing device particularly for attachment to a lathe. In the drawing *A* is a holder supporting the stones *B*, and it consists of two limbs, each in two portions *C* and *D* and *E* and *F*, the limb portions being pivoted one to the other at *G* and *H*, and the limb portions *D* and *F* being pivoted to one another at *J*.*K* and *L* are links each pivoted at one end at *G* and *H* and at the other end



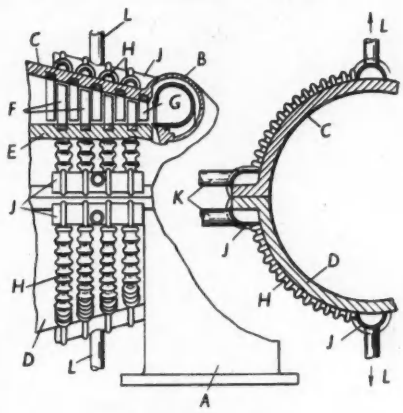
No. 740,020

to a carrier bar *M*, which slides in a guide member *N* which carries a pin *O* in a tool bar *P* which can be held in the slide rest of a lathe. *R* and *S* are adjusting screws for altering the angular positions of the framework and *T* is a clamping and adjusting screw for setting the angular relationship of the two limbs of the holder to suit work of different diameters. In practice, as with the grinding and honing of a crankpin, shown in the lower view of the drawing, the crankshaft is mounted in the lathe centres, and the tool bar *P* is clamped in the slide rest with the axis of the pin parallel to the axis of the crankshaft. The clamping and adjusting screw *T* is loosened to permit the carrier to be opened up and fitted around the crankpin and set at the position holding the limbs *C* and *D* and *E* and *F* in the desired relationship to suit the diameter of the crankpin, and the adjusting screws *R* and *S* are then set to bring the grinding and honing faces of the stones *B* into contact with the work. When the crankshaft is rotated the portion of the carrier carrying the grinding or honing stones executes an orbital motion, the carrier bar *M* sliding in the member *N*, which oscillates about the axis of the pin *O*. As the grinding or honing proceeds the pin *O* is moved through the tool bar, thereby causing the stones to traverse the full width of the crankpin. With the device described it is claimed that crankpins can be ground, honed or lapped at comparatively high rotational speeds, since the grinding, honing or lapping action can proceed automatically until the desired diameter of the crankpin is attained. The grinding, honing or lapping of a spindle or shaft is also described in the specification.—*November* 9, 1955.

STEAM AND GAS TURBINES

740,024.—February 4, 1954, EXTERNAL COOLING ARRANGEMENT FOR CASINGS, Aktiengesellschaft Brown, Boveri et Cie, Baden, Switzerland.

The invention provides an external cooling arrangement for the casings of hot steam and gas turbines which can be easily and cheaply produced, and is readily able to withstand heat stresses; it is characterised by ducts formed by corrugated half-tubes



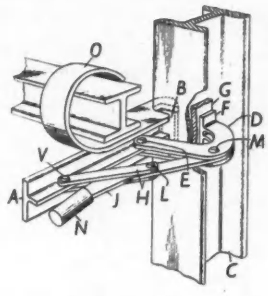
No. 740,024

which are welded externally to the casing parts to be cooled, the cooling medium passing along these ducts. In the drawing a turbine is indicated by inlet conduit *A* and inlet ring channel *B* for the operating medium as well as by upper part *C* and lower part *D* of a casing; furthermore, *E* is a rotor, *F* are running blades, and *G* guide blades; *H* indicates ducts formed by corrugated half-tubes welded to the outside of the casing parts which are to be cooled, the cooling medium flowing along these ducts. Further ducts which are provided with corrugations are indicated at *J*, these serving as collector channels into which a cooling medium—for instance, saturated steam or air—can be introduced at *K* and discharged at *L*. The fact that all the ducts welded to the turbine casing are provided with corrugations, prevents them from fracturing as a result of differences in expansion, which are bound to occur between the hotter parts adjoining the casing wall and the colder external parts.—*November* 9, 1955.

MINING ENGINEERING

738,977. May 6, 1952.—SUPPORTING DEVICES FOR HORSEHEADS IN COAL MINES, The Minister of Fuel and Power, London. (*Inventor: Arthur Thorpe.*)

The invention relates to supporting devices and is particularly concerned with supports or clips for horseheads and the like in use in coal mines. Referring to the drawing, the clip incorporates a bracket *A* of T-section steel, one end of which is bent to form a hook *B* for engaging round one edge of a flange of an I-section arch member *C*. A jaw *D* is connected to the bracket by a pivot *E* near to the hook and is capable of movement clear of the other edge of the flange of the arch member. When in the fully closed position the head *F* of the jaw *D* is a short distance away from the web of the arch member. A piece of wood *G* is inserted in the space between the web and the jaw member. The ends of the toggle link *H* are connected to the bracket and a hand-operated lever or link *J*. The extremity of the lever also connects with the outer part of the jaw *D* at another pivot *M*. The construction is such that when the jaw *D* is fully closed, with the lever *J* right up to the bracket, the centre of the pivot *L* connecting the lever *J* and the link *H* is a short distance inside a straight line drawn between the centre of the other pivot of the link and the pivot *M* at the extremity of the lever *J*. The free end *N* of the lever is fashioned to fit inside the



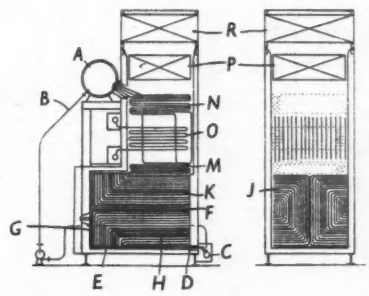
No. 738,977

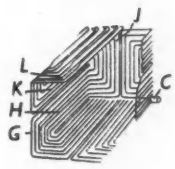
end of a length of pipe, thereby providing a strong leverage to close the jaw. The bracket *A* member carries a cradle *O* through which a horsehead or similar girder may be passed. In addition to the support of horseheads, the clip can also be used for supporting pipes and other equipment.—*October* 26, 1955.

STEAM GENERATORS

739,335. January 8, 1954.—FORCED CIRCULATION STEAM GENERATORS, La Mont International Association, Ltd., 42, Leicester Square, London, W.C.2. (*Inventor: Karl Hans Reppel.*)

The invention relates to an improved arrangement of the evaporating heating surfaces in forced circulation steam generators with water-cooled combustion chamber walls. Referring to the drawing, the boiler





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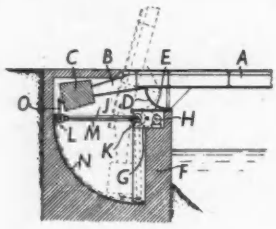
consists of a steam and water drum *A*, from which a circulating pump withdraws water by way of a pipe *B* and discharges it to the distributor header *C*. From this header emanate the evaporating tubes *D* covering the floor *E* of the combustion chamber *F*. Near the front wall of the combustion chamber the tubes run upwards at *G* and cover the front part of the side wall. They are led horizontally along the side wall at *H*, cover the rear wall at *J* and run back towards the front wall, covering the upper part of the side wall at *K*. From there they run upwards covering the roof at *L* and form in their continuation tube banks *M* and *N*. A superheater *O* may be arranged between the evaporator tube banks. Above the tube bank *N* an economiser *P* and an air heater *R* may be installed. A modification of the arrangement of the tube circuit is also shown in the specification. The heating surface arrangement shown is not limited to oil-fired boilers.—*October* 26, 1955.

BASCULE BRIDGES

740,224. March 23, 1954.—OPERATING GEAR FOR ROLLING BASCULE BRIDGES, Aktiengesellschaft für Unternehmungen der Eisen- und Stahlindustrie, Altendorferstrasse 103, Essen, Germany.

The invention aims to combine the advantages of the operating gear which can be used with bascule bridges, having a fixed pivotal axis, with the static advantages of the rolling bascule bridge. As will be seen from the drawing, the main girders *A* of the

bridge carry inward extending arms *B* joined by a counterweight *C*. The arms are provided with runners *D*, which, on the movement of the bridge, roll on tracks *E* on the foundation *F*. In a cavity in the foundation is gearing *G* driven by a motor *H* or by hand, and one end of the rocking arm *J* is pivoted on the gear shaft *K*. Mounted on the other end of the rocking arm is a pinion *L* driven from *K* by a shaft



No. 740,224

M, and bevel gearing which engages the fixed rack *N* on the foundation. The rack is of part circular curvature, and its centre of curvature is on the axis of the shaft *K* about which the rocking arm *J* turns. Between the rocking arm *J* and the arm *B* or counterweight *C* is a yielding connection *O*. Movement is accordingly imparted from the rocking arm to the bridge. Any minor discrepancies between the movement of the rocking arm *J* in a circular arc and the movement of the arm *B* or counterweight *C* in a hypocycloidal path, are taken care of by the yielding of the member *O*.—*November* 9, 1955.

Catalogues and Brochures

FOSTER TRANSFORMERS, Ltd., South Wimbledon, London, S.W.19.—Publications giving details of "Voltage Regulating Equipment," "Mark IIVR/ECV Electronic Constant Voltage Transformer," "Test Equipment," Product list No. 0150 and price lists.

THE EXPORT PACKING SERVICE, Ltd., Imperial Buildings, 56, Kingsway, London, W.C.2.—Brochure entitled "Probing into Packaging," describing the progress made during the past year at the firm's research and development laboratory at Sittingbourne in Kent.

ROWLAND PRIEST, Ltd., Cradley Heath, Staffs.—Catalogue giving details of triple gear chain blocks, worm gear chain blocks, travelling trolleys, overhead cranes, pulley blocks, hydraulic jacks, screw jacks, winches, &c.

W. C. HOLMES AND CO., Ltd., P.O. Box B7, Turnbridge, Huddersfield.—Publication No. 56, giving details of the "Holmes-Connersville RBS Blower" used on pressure or vacuum service for normal industrial purposes.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., Elecfurn Works, Otterspool Way, Watford By-Pass, Watford, Herts.—Illustrated brochure giving details of carbonitriding in batch, rotary drum and shaker hearth furnaces.

R. J. RICHARDSON AND SONS, Ltd., Engineering and Shot Blast Works, Commercial Street, Birmingham, 1.—Folder introducing a new shot blast room capable of accommodating work up to a total weight of 10 tons.

Calendars and Diaries

WE acknowledge receipt of calendars and/or diaries for 1956 from the undermentioned firms :—

MAVOR AND COULSON, Ltd., Bridgeton, Glasgow, S.E.
DISPRO, Ltd., 36–38, Peckham Road, London, S.E.5.
ASHWELL AND NESBIT, Ltd., Barkby Road, Leicester.
MASSEY-HARRIS-FERGUSON (SALES), Ltd., Coventry.
A. MONK AND CO., Ltd., Padgate, Warrington.
AERO RESEARCH, Ltd., Duxford, Cambridge.
BROOK MOTORS, Ltd., Huddersfield, Yorks.
PERMALI, Ltd., Bristol Road, Gloucester.
HIGH DUTY ALLOYS, Ltd., Slough, Bucks.
RANSOMES AND RAPIER, Ltd., Ipswich.
RUSTON-BUCYRUS, Ltd., Lincoln.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Jan. 13*th.*—STOKE AND CREWE BRANCH : Royal Hotel, Crewe, "Heating and Ventilating," 8 p.m.

BRITISH BOTTLER'S INSTITUTE

Mon., Jan. 16*th.*—The Institute of Management, 8, Hill Street, London, W.1, "Heat Utilisation in Our Industry," John Fox, 6.30 p.m.

BRITISH WELDING RESEARCH ASSOCIATION

To-day, Jan. 13*th.*—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "What Can Be Done to Reduce Fatigue Failure and Brittle Fracture ?" R. Weck, 9.30 to 11 a.m.; "Resistance Welding Ferrous and Non-Ferrous Metals," E. V. Beatson, 11.30 a.m. to 1 p.m.; "Processes for Welding Light Alloys," W. G. Hull, 2.30 to 3.30 p.m.; Metallurgical Aspects of Welding Light Alloys," P. T. Houldcroft, 4 to 5 p.m.

CHEMICAL SOCIETY

Thurs., Jan. 19*th.*—Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7, "Recent Progress in the Chemistry of Peptides," 7.30 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Jan. 19*th.*—Caxton Hall, Westminster, London, S.W.1, "Fundamentals of Free Piston Engines and Their Applications," Evelyn S. L. Beale and Patrick Watson, 2 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Jan. 17*th.*—GLOUCESTER AND CHELTENHAM CENTRE : Fleece Hotel, Westgate Street, Gloucester, "Shop and Store Lighting," R. L. C. Tate, 6.30 p.m.——LIVERPOOL CENTRE : Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool, "Lighting in Offices," G. B. Lancaster, 6 p.m.
Wed., Jan. 18*th.*—N. LANCASHIRE GROUP : N.W. Electricity Board, 19, Friargate, Preston, "Light and its Effect on Plant Growth and Egg Production," A. E. Canham, 7.15 p.m.——TEES-SIDE GROUP : Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "X-rays in Industry and Medicine," J. E. Hood and G. Whiteley, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Jan. 18*th.*—KENT BRANCH : Bull Hotel, Rochester, Open Forum, 7 p.m.
Fri., Jan. 20*th.*—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, Ministry of Works Films, 7.30 p.m.——BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, "Smoke Abatement," J. Lewis, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

To-day, Jan. 13*th.*—TEES-SIDE BRANCH : Teesdale Hall, Head, Wrightson and Co., Ltd., Thornaby-on-Tees, "Pattern Equipment—Present-day Trends and the Future of the Patternmaking Craftsmen," L. Brown, 7.30 p.m.
Sat., Jan. 14*th.*—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, "Modern Cupola Practice," W. H. Bamford, 3 p.m.——NEWCASTLE BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "Some Foundry Techniques," C. R. van der Ben and H. Haynes, 6 p.m.——SCOTTISH BRANCH : Royal Technical College, Glasgow, "Jobbing Production of Light Alloy Castings," A. S. H. Sawers, 3 p.m.
Tues., Jan. 17*th.*—SLOUGH SECTION : Lecture Theatre, High Duty Alloys, Ltd., Slough, "Foundry Dust Hazards," E. B. James and W. B. Lawrie, 7.30 p.m.
Wed., Jan. 18*th.*—LONDON BRANCH : Waldorf Hotel, London, W.C.2, "Latest Developments in Spheroidal-Graphite Iron," W. W. Braidwood, followed by a film, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Jan. 18*th.*—JOINT MEETING : Institution of Civil Engineers, Great George Street, London, S.W.1, "The Utilisation of Steam and Power in Modern Gasworks and Coking Plants," L. C. Clark, 5.30 p.m.
Fri., Jan. 20*th.*—SCOTTISH SECTION : Royal Technical College, Glasgow, "Modern Gas Production," J. E. Tully and D. J. A. Mansell, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Jan. 16*th.*—STUDENT LECTURE : 85, Minories, London, E.C.3, "Turbo-Electric Propulsion Machinery," R. J. Hayes, 6.30 p.m.
Thurs., Jan. 19*th.*—SOUTHERN JOINT BRANCH : College of Technology, Portsmouth, "The Cathodic Protection of Ships Against Sea Water Corrosion," L. T. Carter and J. T. Crennel, 7.30 p.m.——KINGSTON-UPON-HULL AND E. MIDLANDS SECTION : Royal Station Hotel, Kingston-upon-Hull, "Trawling and Freezing at Sea (Fairtry)," W. Lochridge, 7.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Jan. 20*th.*—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Some Meteorological Aspects of High-Level Navigation," "Jet Streams in Flight," B. C. Frost, "Forecasting Jet Streams," J. K. Bannon and T. H. Kirk, 5 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Jan. 13*th.*—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "The Development of the Gas Turbine for Road Transport," P. A. Phillips, 7 p.m.
Tues., Jan. 17*th.*—MIDLANDS CENTRE : Exchange and Engineering Centre, Stephenson Place, Birmingham, "The Development of Passenger Road Transport in Sweden, Particularly in Sweden," Carl Hammarskjold, 7.30 p.m.
Thurs., Jan. 19*th.*—LONDON CENTRE : Royal Society of Arts, John Adam Street, W.C.2, "The Development of Passenger Road Transport in Sweden, Particularly in Sweden," Carl Hammarskjold, 6.30 p.m.——YORKSHIRE CENTRE : Great Northern Hotel, Wellington Street, Leeds, 1, "Road and Rig Testing of Prototype Road Transport Vehicles and Their Components," J. H. Alden, 7.30 p.m.

INSTITUTE OF WELDING

To-day, Jan. 13*th.*—E. MIDLANDS BRANCH : College of Art, Derby, "Modern Techniques for Welding Aluminium and its Alloys," J. E. Tomlinson, 7.15 p.m.
Wed., Jan. 18*th.*—MANCHESTER BRANCH : Stockport College for Further Education, Wellington Road South, Stockport, Manchester, "The Planning and Layout of a Modern Welding Shop," R. M. Watts, 7.15 p.m.——W. OF SCOTLAND BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Construction and Welding of the Fourth 'Ark Royal,'" H. R. P. Chatten, 6.30 p.m.——WOLVERHAMPTON BRANCH : Victoria Hotel, Wolverhampton, "Welding at the Atomic Plants," I. H. Hogg, 7.30 p.m.
Thurs., Jan. 19*th.*—SOUTHAMPTON BRANCH : Technical College, St. Mary's, Southampton, "Oxygen Cutting," L. L. Arundale, 7 p.m.——S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Hydrogen in Weld Metal and Hardened-Zone Cracking," H. G. Vaughan, 7 p.m.
Fri., Jan. 20*th.*—SHEFFIELD BRANCH : College of Technology, Rotherham, "Some Fabrication Aspects in Atomic Energy," R. Glanville, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 17*th.*—Great George Street, London, S.W.1, "The Experimental and Mathematical Analysis of Arch Dams, with Special Reference to Dokan," D. N. de G. Allen, Letitia Chitty, A. J. S. Pippard and R. T. Severn, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 16*th.*—JOINT MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Advanced Courses for Engineers in Industry," Willis Jackson, H. D. Morgan and G. F. Mucklow, 5.30 p.m.
Tues., Jan. 17*th.*—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, "A New Meter for the Kilovolt-Ampere Demand Charge," P. Baxter, 5.30 p.m.——N. MIDLAND CENTRE : Central Electricity Authority, 1, Whitehall Road, Leeds, 1, "The Installation of Metal-Sheathed Cables Out of Doors on Spaced Supports," W. Holttum, 6.30 p.m.——S.E. SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "The Engineers' Contribution to the Conservation of Natural Resources," Sir Harold Hartley, 7 p.m.
Thurs., Jan. 19*th.*—UTILIZATION SECTION : Savoy Place, London, W.C.2, "Age and the Incidence of Fires in Electrical Installations," L. Gosland, 5.30 p.m.——S. MIDLAND CENTRE : Town Hall, Birmingham, Faraday Lecture, "Mining Electrically," B. L. Metcalfe, 7 p.m.——N. MIDLAND CENTRE : Yorkshire Electricity Board, Ferensway, Hull, "The Development of Power Station Construction in Leeds and the Surrounding Area," F. Barrell, 7.15 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Jan. 18*th.*—GENERAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Limits and Fits from the Railway Point of View," E. R. Brown, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 13*th.*—GENERAL MEETING, HYDRAULICS GROUP : 1, Birdcage Walk, London, S.W.1, "Water-Ring Self-Priming Pumps," E. Crewdson, 5.30 p.m.
Mon., Jan. 16*th.*—JOINT MEETING : 1, Birdcage Walk, London, S.W.1, "Advanced Courses for Engineers in Industry," H. D. Morgan, G. F. Mucklow and Willis Jackson, 5.30 p.m.
Tues., Jan. 17*th.*—AUTOMOBILE DIVISION DISCUSSION : 1, Birdcage Walk, London, S.W.1, "The Value of Racing to the Car Industry," 6.45 p.m.
Wed., Jan. 18*th.*—GENERAL MEETING IN CONJUNCTION WITH THE BRITISH NUCLEAR ENERGY CONFERENCE : Institution of Civil Engineers, Great George Street, London, S.W.1, "The Use of Sodium and of Sodium-Potassium Alloy as a Heat Transfer Medium," W. B. Hall and T. I. M. Crofts, 5.30 p.m.
Fri., Jan. 20*th.*—GENERAL MEETING : 1, Birdcage Walk, London, S.W.1, Thomas Lowe Gray Lecture, "Marine Reduction Gearing," A. W. Davis, 5.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Jan. 19*th.*—Geological Society, Burlington House, Piccadilly, London, W.1, "A Decade of Progress in Canadian Mining (1945–1954)—Part II," H. A. Graves, 5 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., Jan. 18*th.*—INFORMAL MEETING : Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "Transmission Testing Equipment—Do Current Designs Meet Our Needs ?" S. H. Chisman and R. W. Lockton, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Jan. 13*th.*—EASTERN COUNTIES SECTION : Diocesan Hall, Tower Street, Ipswich, "Factory Electrical Layout and the Production Engineer," C. A. Marriott ; "A Special Tapping Machine," L. A. Childs ; "Flaw Detector," E. J. Cove, 7.30 p.m.——W. WALES SECTION : Central Library, Alexandra Road, Swansea, "Electronics for Production," J. A. Sargrove, 7.30 p.m.
Mon., Jan. 16*th.*—DERBY SECTION : College of Art, Derby, "Automation—Some Managerial Problems," F. Garner, 7 p.m.——N.E. SECTION : Neville Hall, Newcastle upon Tyne, "Production Engineering Establishment," R. B. Neary, 7 p.m.——STOKE-ON-TRENT SECTION : Hanley Town Hall, Hanley, Stoke-on-Trent, "Automatic Linking Devices," J. A. Hunt, 7.15 p.m.
Wed., Jan. 18*th.*—BIRMINGHAM SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Production of Heavy Electrical Rotating Machinery," L. G. Hawkins, 7 p.m.——S. ESSEX SECTION : Mid-Essex Technical College, Chelmsford, "Indirect Incentives," T. A. Mason, 7.30 p.m.——WESTERN SECTION : University Engineering Laboratories, University Walk, Bristol, 8, "Experiences in Engineering Design in a Chemical and Textile Factory," H. E. B. Young, 7.15 p.m.
Thurs., Jan. 19*th.*—N. IRELAND SECTION : Kensington Hotel, College Square East, Belfast, "Tracer Control of Machine Tools," J. Lund, 7.30 p.m.——PRESTON SECTION : Lucas Assembly Room, Yorkshire Street, Burnley, "Who is Responsible for Industrial Prosperity," Sir Walter Puckey, 7.30 p.m.——SOUTHERN SECTION : Polygon Hotel, Southampton, "Production Problems on the 'Javelin,'" W. W. W. Downing, 7.15 p.m.——LONDON SECTION : Royal Empire Society, Northumberland Avenue, London, W.C.2, "Practical Marginal Costing," W. E. Harrison, 7 p.m.——READING SECTION : Social Club, Petters, Ltd., Staines, "Electronics in Industry," J. A. Sargrove, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 17*th.*—SCOTTISH BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Aluminium Alloy Structures," D. V. Pike, 6 p.m.
Wed., Jan. 18*th.*—LANCASHIRE AND CHESHIRE BRANCH : Liverpool Engineering Society, Dale Street, Liverpool, "The Calculations of Critical Loads for Rigid Frames," A. Bolton, 6.30 p.m.——WALES AND MONMOUTHSHIRE BRANCH : Mackworth Hotel, Swansea, "Description of Neath By-Pass Constructional Work," A. F. Allen, 6.30 p.m.
Fri., Jan. 20*th.*—S.W. COUNTIES BRANCH : Duke of Cornwall Hotel, Plymouth, "The Development of Plastic Design," J. F. Baker, 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 13*th.*—ORDINARY MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "High-Altitude Passenger Flying with Special Reference to Air Treatment," Barry T. Turner, 7 p.m.
Fri., Jan. 20*th.*—INFORMAL MEETING : Pepys House, 14, Rochester Row, London, S.W.1, "Some Notes on the Flow of Plastic Solids," R. F. Twist, 7 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Jan. 19*th.*—Mining and Technical College, Wigan, "Planning High-Speed Drifting," R. Driver, 3.15 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Jan. 13*th.*—MINING INSTITUTE, Newcastle upon Tyne "The Modern Manufacture of Steel Plate for Shipbuilding," T. F. Pearson, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., Jan. 18*th.*—11, Upper Belgrave Street, London, S.W.1, "Continental Concrete Roads," D. R. Sharp, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 17*th.*—SECTION LECTURE : 4, Hamilton Place, London, W.1, "Crack Detection in Aircraft Structures," W. Deck, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Tues., Jan. 17*th.*—GENERAL MEETING : 12, Great George Street, London, S.W.1, "Development Plans and Their Provision for Industry," S. L. G. Beaufoy, 5.30 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Jan. 16*th.*—The University Building, St. George's Square, Sheffield, Presidential Address, 7.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Jan. 13*th.*—39, Elmbank Crescent, Glasgow, "Notes on Basic Open-Hearth Melting Shop Practice," J. Gibson, 6.45 p.m.